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A REPORT ON A LOCATION STUDY

BILLINGS TO BIGHORN LAKE

BIGHORN CANYON NATIONAL RECREATION AREA ACCESS ROAD

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A REPORT ON
A LOCATION STUDY

BILLINGS TO BIGHORN LAKE

BIGHORN CANYON NATIONAL RECREATION AREA ACCESS ROAD

July, 1971

PREPARED FOR
MONTANA HIGHWAY COMMISSION

BY

MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS
BILLINGS-HELENA, MONTANA

TABLE OF CONTENTS

Page

Figure 1 - General Location Plan

INTRODUCTION

Foreword 1

Figure 2 - Location Plan of Basic Alternates 1 and 2 6

Figure 2A - Location Plan of Other Alternates Considered (Alt. 3-9) 8

Figures 3 through 8 - Oblique Photo Location Layouts 10-15

LOCATION AND GEOMETRICS

General Information 16

Alternate No. 1 17

Alternate No. 2 18

Other Alternates Considered (Alt. 3-9) 19

Geometrics 21

Table 1 - Geometric Features 22

GEOLOGY

Purpose and Scope 23

Geography 23

Geologic History 24

Table 2 - Geologic Sections 26

Figure 9 - General Geologic Map 27

Effects of Geology on Engineering Design 28

Figure 10 - Geologic Terraces & Alluvium 29

Geologic Evaluation 30
Alternate No. 1 30
Alternate No. 2 33

Comparison of Geology on Alternates 1 and 2 35

Geologic Evaluations of Existing Roads 35

HYDRAULICS AND DRAINAGE

Stream Flow Study 37

Drainage Summary 39

TABLE OF CONTENTS - Continued

Page

HYDRAULICS AND DRAINAGE - cont'd.

Figure 11 - Peak Flow Curve. 40

Preliminary Drainage Structure Design 41

Subsurface Drainage for Roadbed Stability 41

DESIGN STANDARDS AND CRITERIA

General Information 43

Design Factors 43

Typical Roadway Design 44

Figure 12 - Typical Roadway Section 45

ADDITIONAL CONSIDERATIONS

Social Economic and Environmental Effects 47

Right of Way and Access 48

Utilities 49

Local Service and Maintenance of Traffic 49

ECONOMIC ANALYSIS

General Information 51

Basis for Traffic Forecasts 51

Basis for Construction Cost Estimates 52

Annual Cost Determinations 53

Basis for Road User Operating Cost Estimates 53

Table 3 - Vehicle Operating Costs 54

Cost Summary and Conclusions 55

Table 4 - Construction Cost Comparison 56

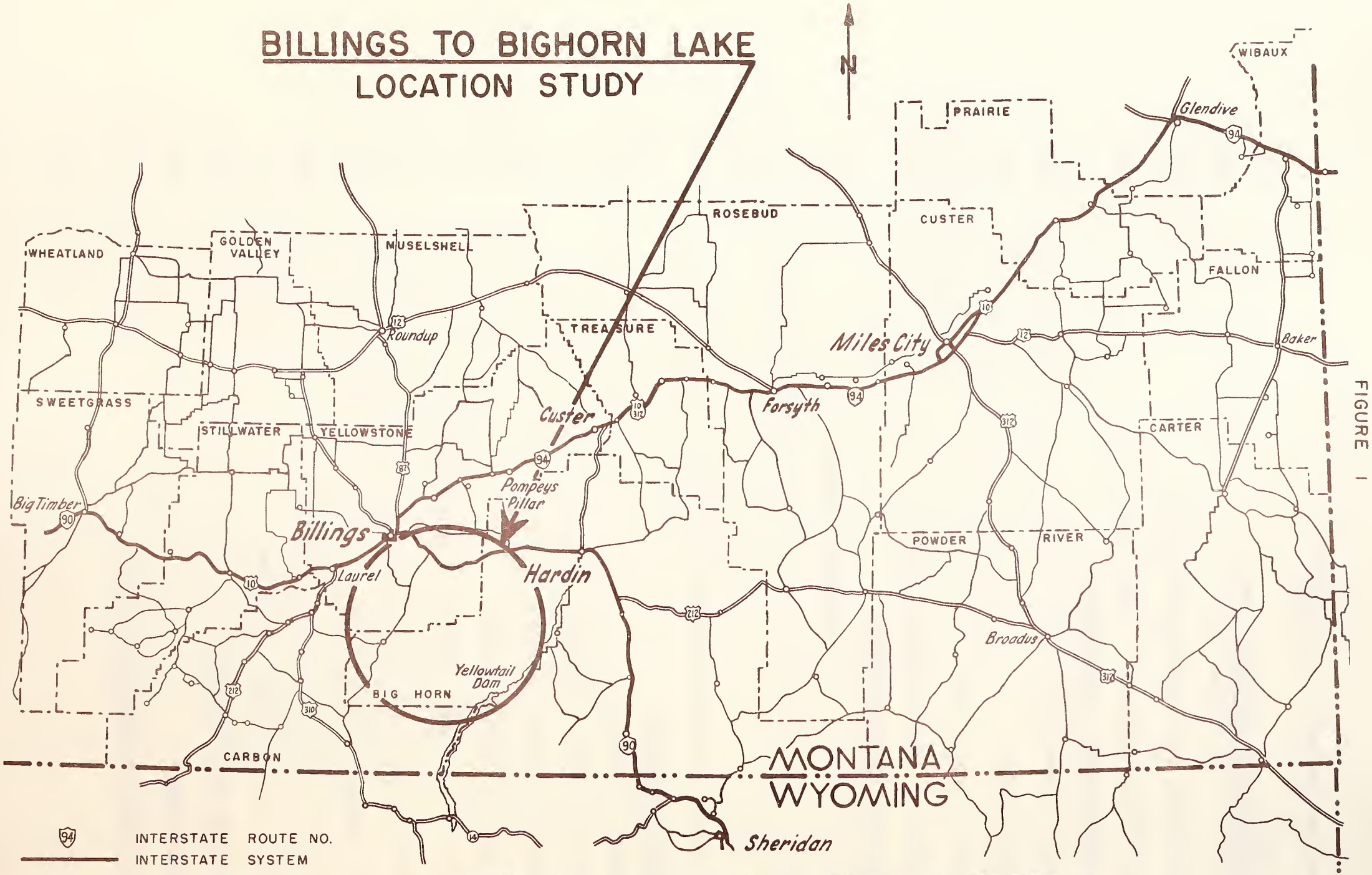
Table 5 - Annual Cost Comparison 57

MEETINGS AND CONFERENCES 58

CONCLUSIONS 61

PLAN-PROFILE, ALTERNATES 1 AND 2

BILLINGS TO BIGHORN LAKE
LOCATION STUDY



MAP OF SOUTHEASTERN MONTANA

FIGURE 1

INTRODUCTION

FOREWORD

The completion of Yellowtail Dam and the subsequent development of recreation facilities around Big Horn Lake in south central Montana, has created an urgent need for a shorter all season highway from Billings to the new recreation area.

Information received from the Montana Highway Commission indicates that 660,000 annual visitations to this area are expected currently and this number may nearly triple by the year 2000. A large percentage of the trips will originate in Billings which, according to 1970 census data, is the largest city in Montana and in the past ten years has had a 16.5% population increase, the highest of any major city in the State.

Yellowtail Dam impounds the largest lake within a 100 mile radius of Billings. The recommended route would reduce the present 88 mile trip from Billings to the lake via Hardin to just over 50 miles which makes this area the only one of its size available for water sports which could conveniently be used for a one day outing.

Recreation oriented drivers are not the only ones who would benefit from this new road. Local ranchers would enjoy their first all weather access into the area and the route would help to complete the road network planned by the Crow Indian Tribe and the Bureau of Indian Affairs. Tourists could also make use of it for their trips from Wyoming north to the Billings area.

The Big Horn Canyon National Recreation Area with its continually expanding leisure time facilities, provides an attraction which is increasingly in demand by the public. The facilities can only be used to

their fullest advantage if the best possible access to the area is provided.

This report covers alternate road location studies for providing access from Billings, Montana to the vicinity of Yellowtail Dam and Bighorn Lake. It was authorized through an agreement dated July 17, 1969 between the Montana State Highway Commission and Morrison-Maierle, Inc., Consulting Engineers.

The project area, as shown on Figure 1, is located in Yellowstone and Big Horn Counties and extends from Billings southeasterly to Yellowtail Dam and Bighorn Lake. The major portion of this area is within the boundaries of the Crow Indian Reservation.

A "Location Plan of Basic Alternates 1 and 2", Figure 2, follows this Introduction. It serves as a key map to show the alternate locations presented in detail in the following sections. Figure 2A shows other alternates which were considered but not studied in as much detail. They are discussed later in the report.

Nine alternates were given preliminary consideration and they were narrowed to two for full presentation. In selecting the alternate routes to present, emphasis was placed on using existing paved roads and common alignment with other planned roads as a matter of practicability. Thus the amount of new construction necessary to provide a continuous paved access road from Billings to the Bighorn Canyon National Recreation Area was kept to a minimum. Both Alternates No. 1 and No. 2 utilize 16.0 miles of the paved Federal Aid Secondary Highway No. 416 (FAS416). This road crosses the Yellowstone River on an extension of South Billings Boulevard, then follows Blue Creek and crosses over the divide to the junction

of FAS416 and Pryor Creek road. New construction is under contract at this time on a portion of FAS 416. A New bridge across the Yellowstone River and the new alignment on the approach sections are to be completed in the near future. With this new piece of construction, the updating on FAS 416 has taken a big step toward handling the anticipated traffic that will be generated by a road to Bighorn Lake. Alternate No. 1 then follows the paved Pryor Creek Road southerly for 7.8 miles to a point near the mouth of Hay Creek. New road construction would begin at this point and extend 29.1 miles southeasterly to a junction with the proposed National Park Service Road near Bighorn Lake.

New road construction on Alternate No. 2 would begin at the junction of Pryor Creek Road and FAS416 near East Wets Creek and head southeasterly for 34.5 miles to a junction with the proposed National Park Service Road near Bighorn Lake, some 3 miles northeasterly of the terminus of Alternate No. 1.

The Agreement outlined two general corridors to be studied as possible route alternates. Alternate No. 1 conforms to the requirements of the first corridor. The second corridor suggested for study was to begin about 15 miles east of Billings on Interstate 90 and extend south and southeasterly to end near Yellowtail Dam. A considerable amount of preliminary investigation was done on this particular route before the decision to abandon it was made. Some of the factors which made this route less desirable are listed below:

(1) Out of direction travel and the added amount of new road construction.

(2) Necessity of constructing a new interchange on I-90. This would be costly and is not necessary with the other alternate.

(3) The rough terrain immediately to the south of the Interstate, which increased construction costs and had steeper grades.

These factors alone seemed to justify investigation of other routes and at a conference with Montana State Highway and Bureau of Public Roads Engineers held on January 12, 1970, the decision was made to abandon further study of this route and instead to investigate the route now labeled Alternate No. 2.

On both Alternates, separate construction costs have been included for new construction and for improving segments of the existing paved County Roads which would be used as a part of the alternate routes. Road User Costs were calculated for both Alternates as well as for a route from Billings to Yellowtail Dam via I-90 to Hardin thence via Federal Aid Secondary Highway No. 313 to the Dam.

The primary function of the road under study is to provide more direct access from Billings to Bighorn Lake. Secondary benefits would include providing access to home sites and ranch headquarters along the route, and to consider the needs of the Crow Indians for travel between Pryor and St. Xavier. In April of 1968, the Montana State Highway Commission submitted a map to the Crow Indian Tribal Council showing two alternate routes for the Billings-Bighorn Lake Road. Alternate Route No. 1, as presented in this report closely conforms to the alternate route preferred by the Crow Tribal Council. This was stated in a letter dated January 3, 1969, to the State Highway Engineer from the Crow Tribal Chairman. Their preference for Alternate No. 1 is undoubtedly due to the fact that approximately 15 miles of this route could be used as a part of what appears to be the most practical route for a Pryor to St. Xavier Road. Of all their Reservation Road System needs, the Crow Indians have

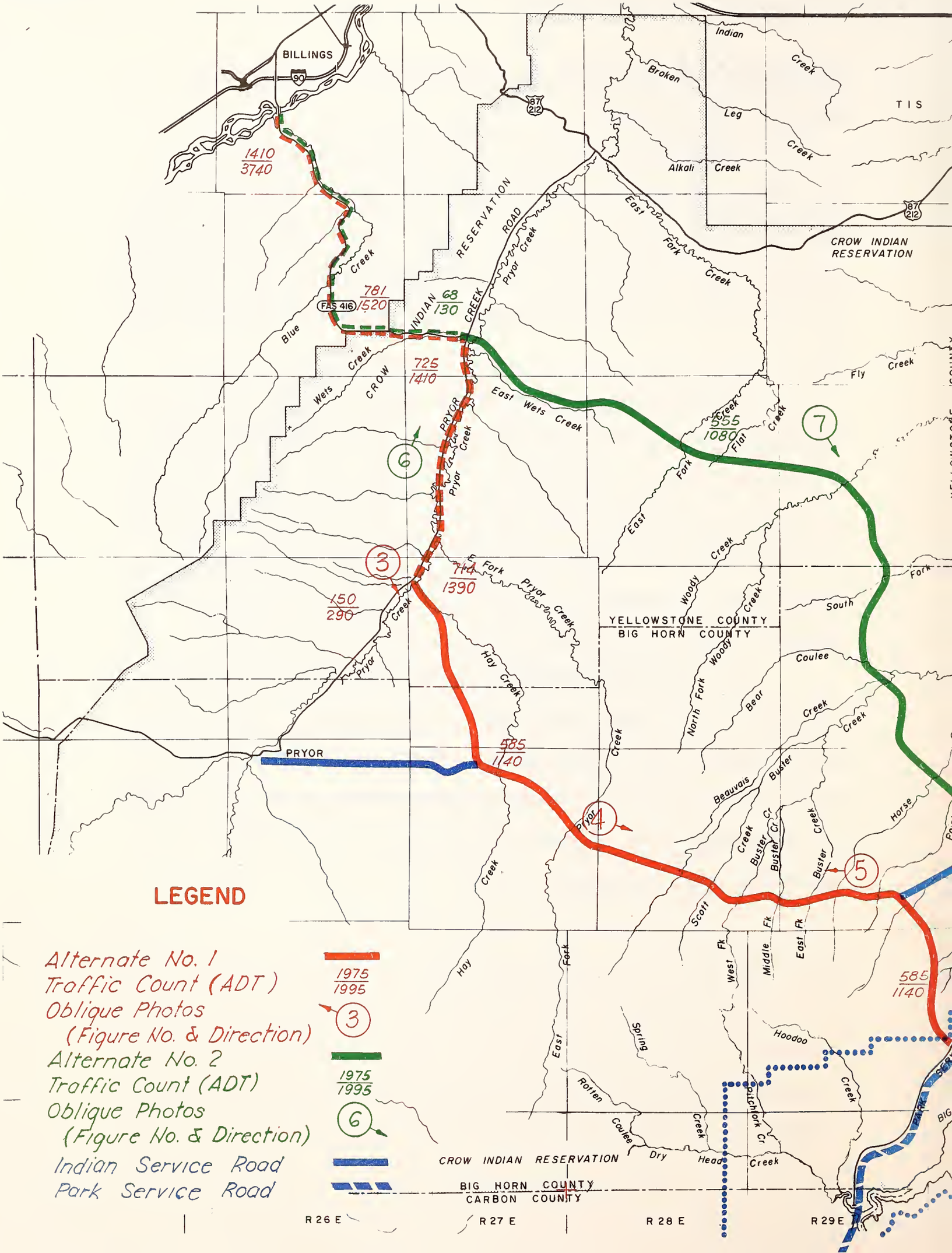
assigned the highest priority to a road easterly from Pryor to St. Xavier as shown on Figure 2.

An important consideration in the economic analysis, which is not reflected in the cost comparisons, is that about 15 miles of Alternate No. 1 coincides with a portion of the proposed Indian Service Road from Pryor to St. Xavier. This would eliminate the need for constructing parallel routes. No part of Alternate No. 2 would serve this dual function.

The information presented in this report is the result of extensive engineering study by the Consultant. All route possibilities which seemed practical and economically feasible within the limits prescribed in the Agreement were investigated. The 104 miles of alternate route presented (52.9 miles for Alternate No. 1 and 50.5 miles for Alternate No. 2) represents the results of a process of elimination based on a relatively thorough cost study of several alternates.

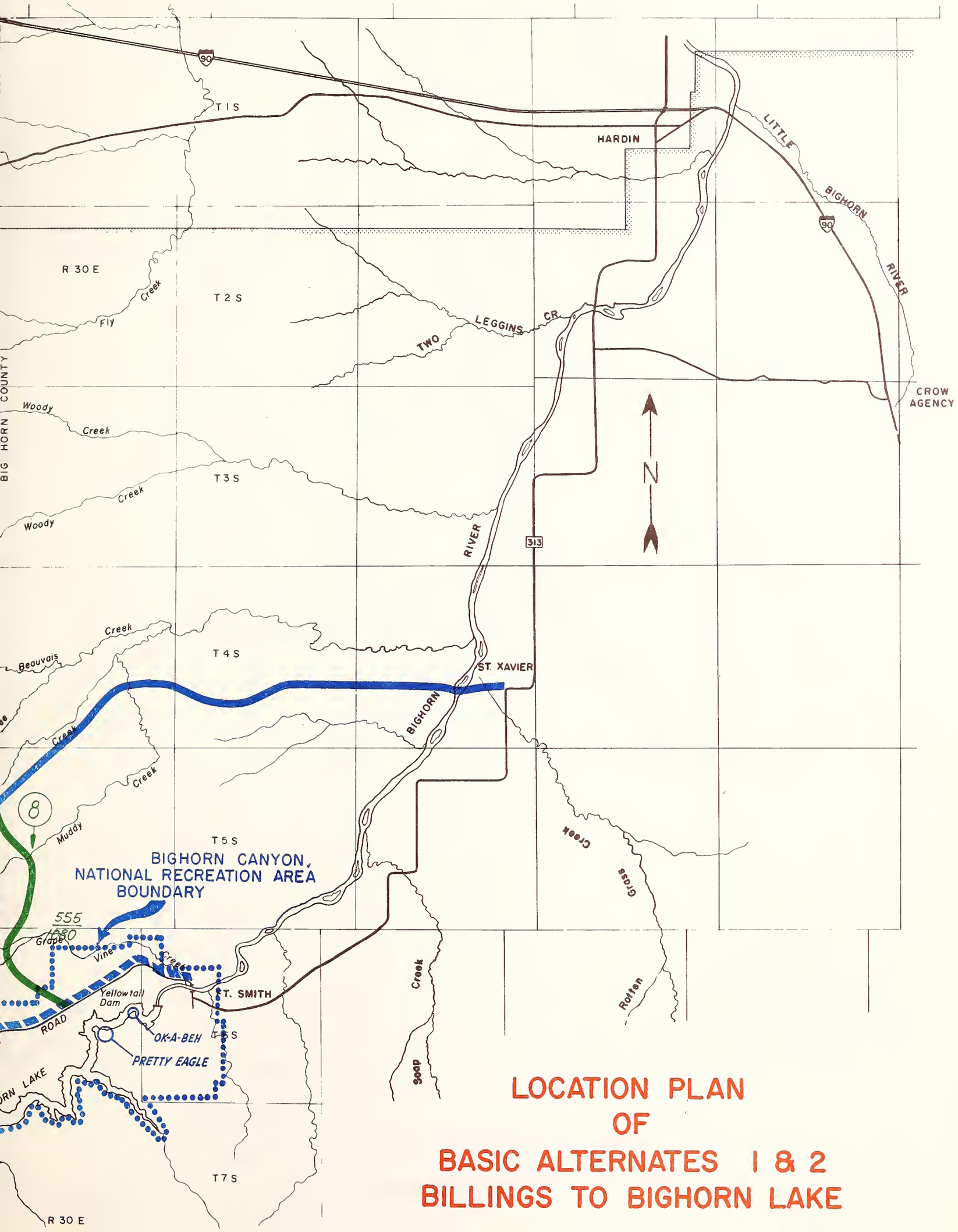
This study has been based on aerial photographs furnished by the Montana State Highway Department and U.S. Geological Survey contour maps. Numerous field inspections and flights over the study area were made to more accurately interpret and make the best use of this mapping and photographic data. Figures 3 through 8 are oblique photos showing the two alternate alignments.

FIGURE 2



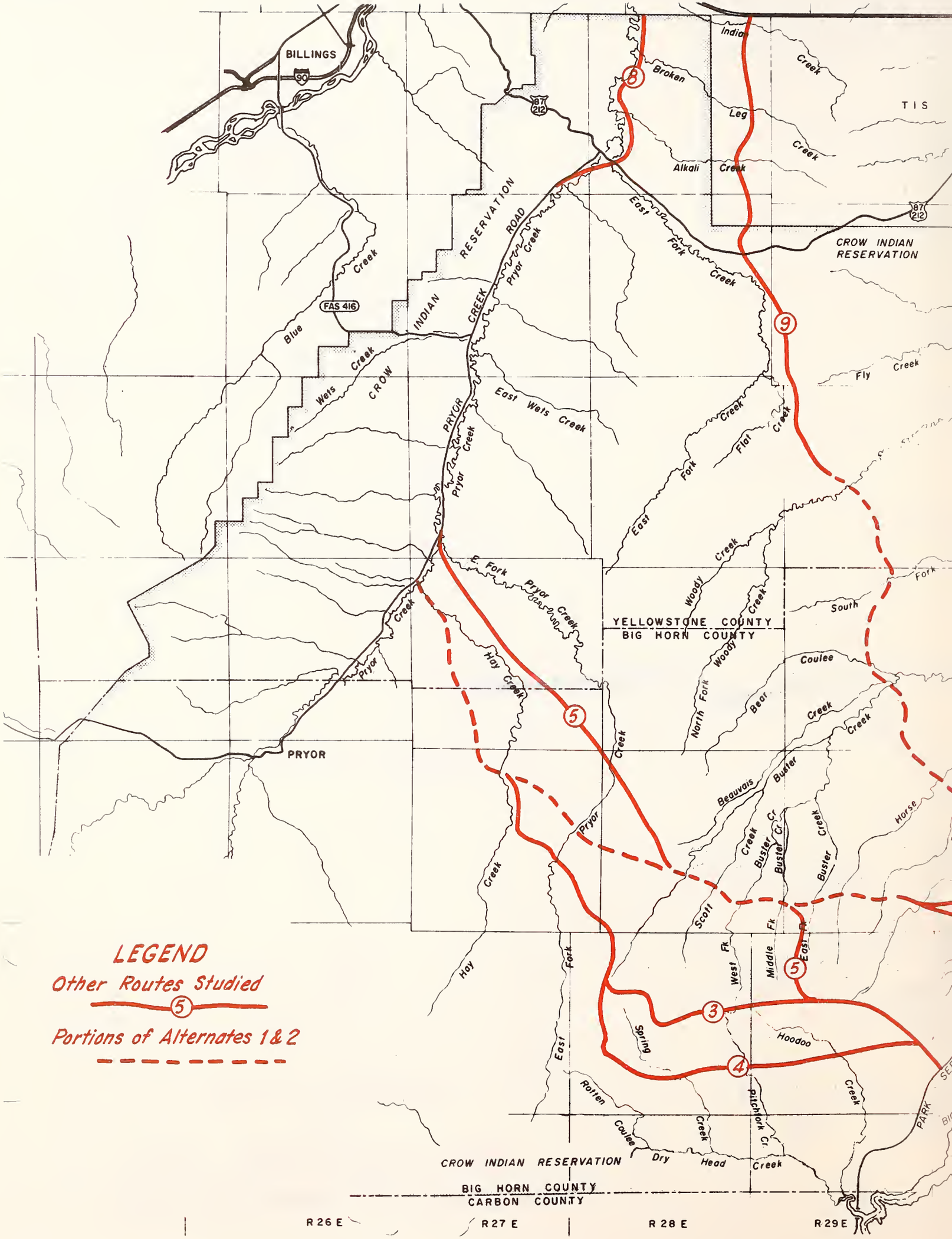
LEGEND

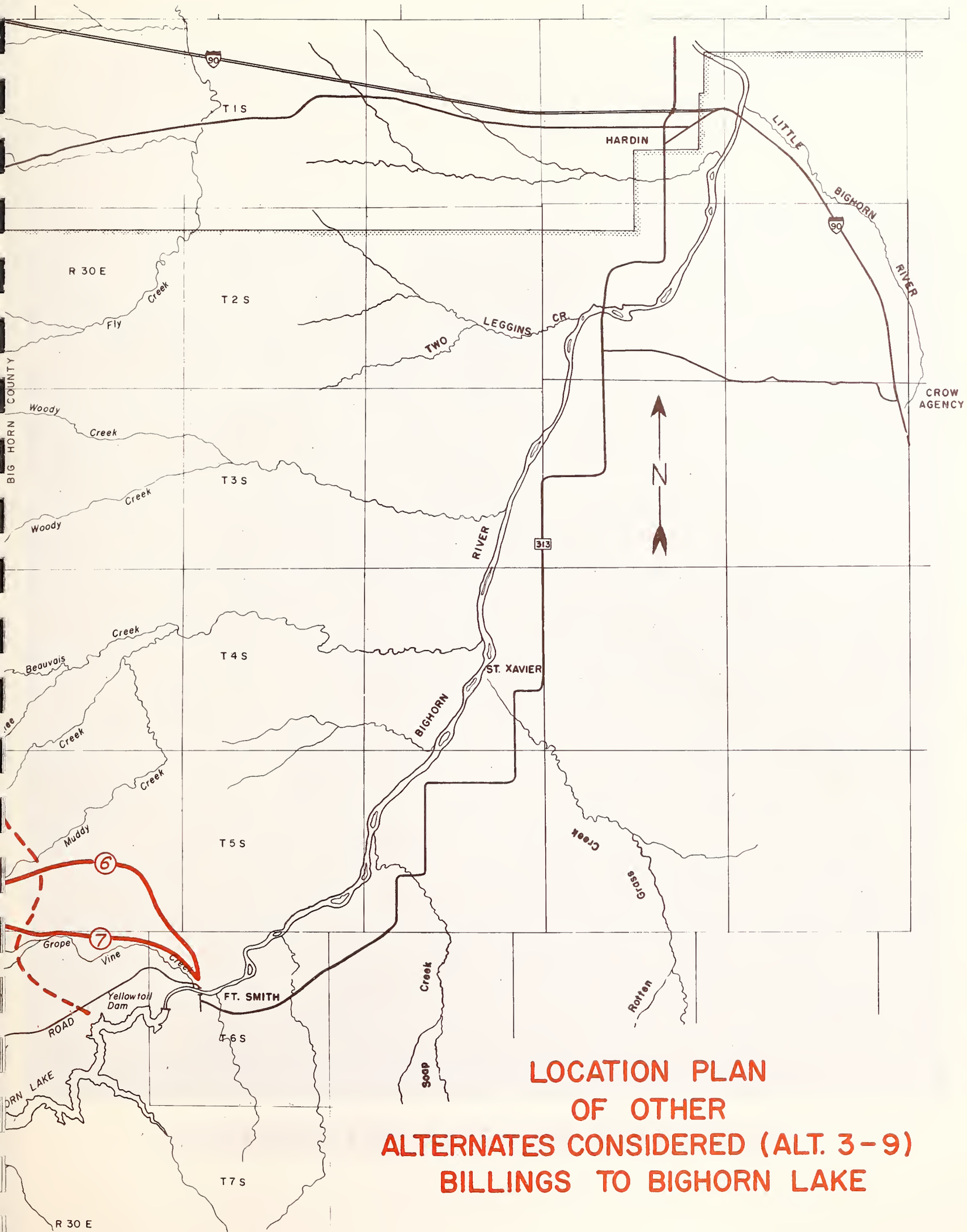
- Alternate No. 1
- Traffic Count (ADT) — 1975 / 1995
- Oblique Photos (Figure No. & Direction) — 3
- Alternate No. 2
- Traffic Count (ADT) — 1975 / 1995
- Oblique Photos (Figure No. & Direction) — 6
- Indian Service Road — CROW INDIAN RESERVATION
- Park Service Road — BIG HORN COUNTY / CARBON COUNTY



LOCATION PLAN OF BASIC ALTERNATES 1 & 2 BILLINGS TO BIGHORN LAKE

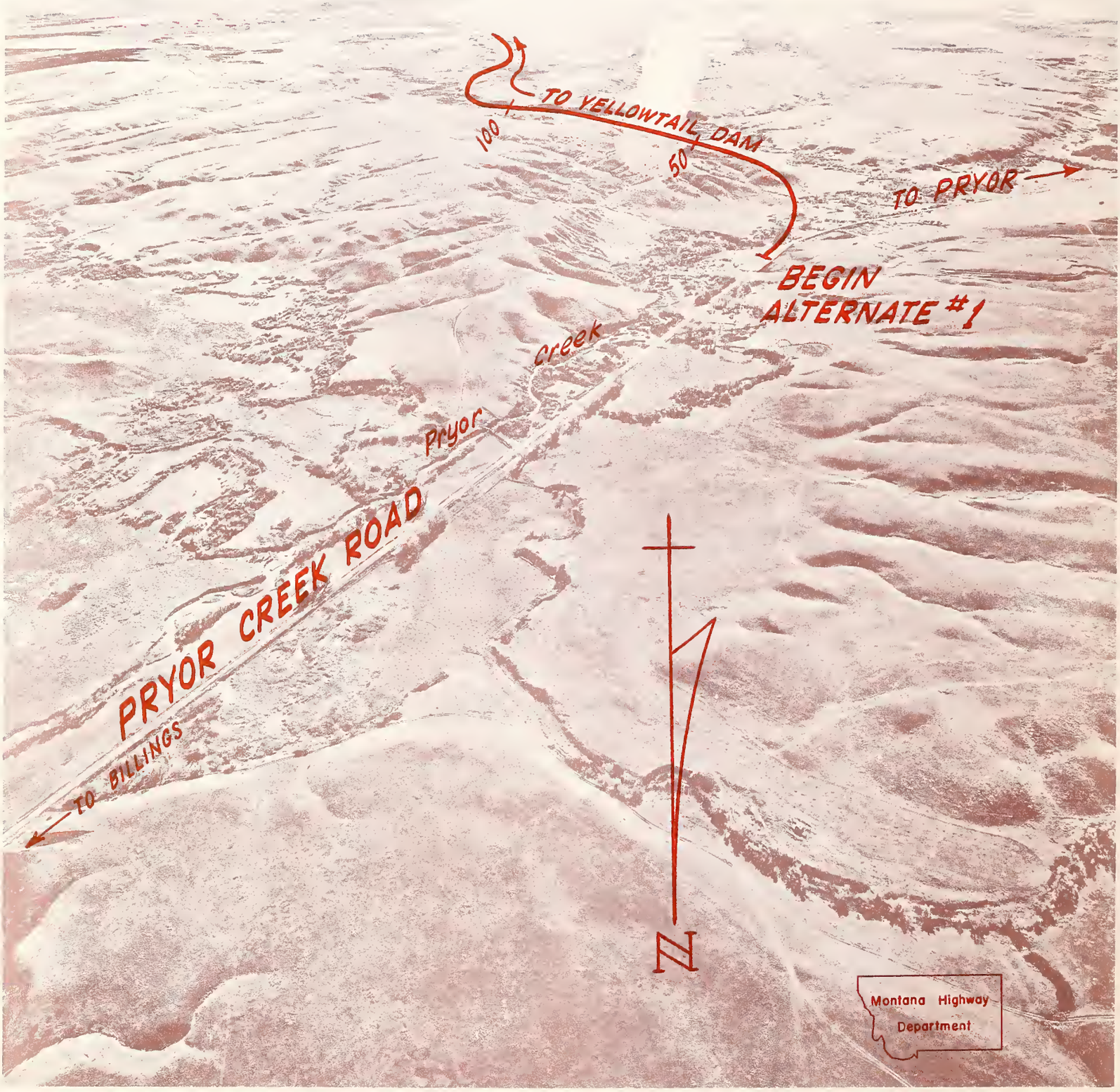
FIGURE 2 -A


BILLINGS
90
87
212
Broken
Leg
Alkali
Creek
T I S
CROW INDIAN
RESERVATION
ROAD
INDIAN
CREEK
RESERVATION
Pryor Creek
East Fork
Blue
Wets
CROW
PRYOR
East Wets Creek
FAS 416
Fly
Flat
Woody
South
Fork
Bear
Coulee
North Fork
Beauvais
Buster
Horse
Scott
Hay
Spring
Hoodoo
Rotten
Pitchfork Cr
Dry
Head
PARK
YELLOWSTONE COUNTY
BIG HORN COUNTY
PRYOR
CROW INDIAN RESERVATION
BIG HORN COUNTY
CARBON COUNTY
R 26 E
R 27 E
R 28 E
R 29 E
LEGEND
Other Routes Studied
Portions of Alternates 1 & 2



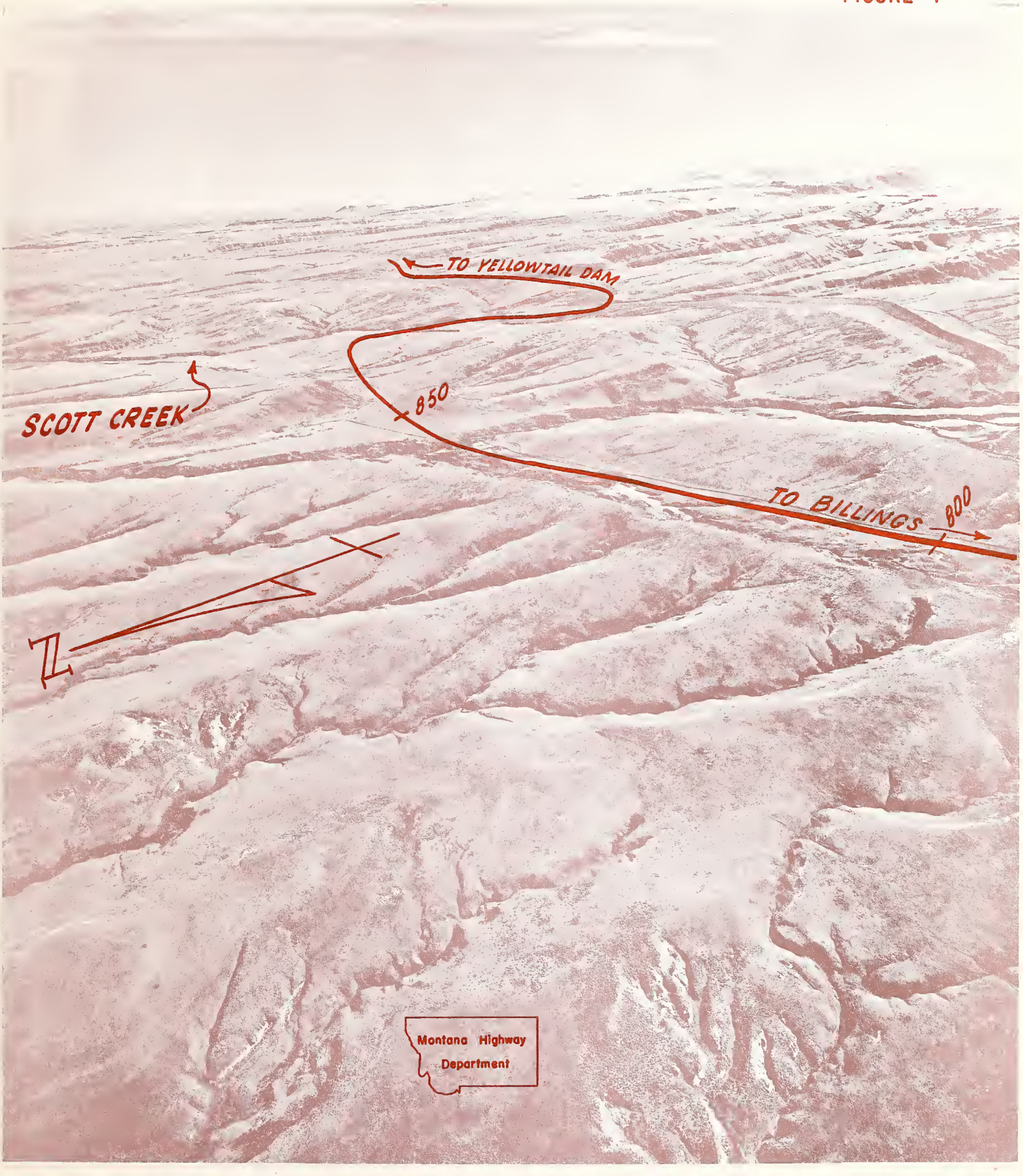
LOCATION PLAN OF OTHER ALTERNATES CONSIDERED (ALT. 3-9) BILLINGS TO BIGHORN LAKE

FIGURE 3



ALTERNATE NO. 1 LOOKING SOUTH

FIGURE 4



ALTERNATE NO. 1 LOOKING SOUTHEAST

FIGURE 5

ALTERNATE NO. 1 LOOKING WEST

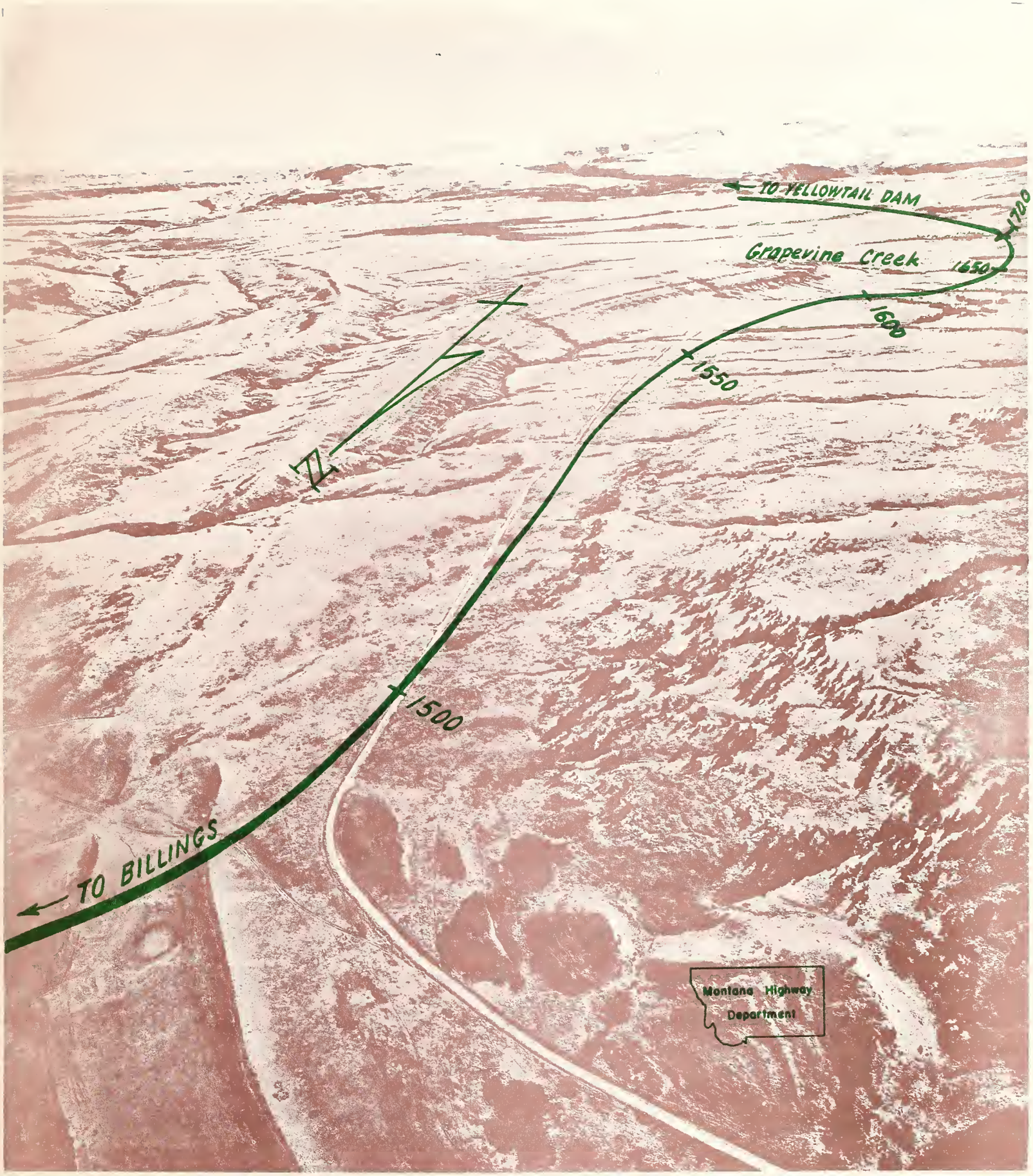
FIGURE 6

ALTERNATE NO.2 LOOKING NORTHEAST

FIGURE 7

ALTERNATE NO. 2 LOOKING SOUTH

FIGURE 8



ALTERNATE NO.2 LOOKING SOUTHEAST

LOCATION AND GEOMETRICS

General Information

The area of study includes the dry farming and grazing land of the Blue Creek, Pryor Creek and Beauvais Creek drainages which lie between Billings and Bighorn Lake. Although the locations shown have been investigated in considerable detail, they represent broad-band locations and minor deviations of alignment and grade may be found to be desirable when final design work is undertaken.

This study covers in detail two alternate routes as shown on Figure 2. The alignments and grades are portrayed on the Plan-Profile Sheets at the end of this report.

Preliminary evaluation of several prospective locations resulted in the decision to study in final detail two alternate combinations. Many other routes were investigated in sufficient detail to eliminate them as being less economical or less desirable than the ones presented. Some of the more note-worthy of these are discussed later in this section and are shown on Figure 2A.

The alignment and grade studies for Alternates 1 and 2 were made from U.S. Geological Survey contour maps, field surveys and aerial photography. The contours on most of these maps were at twenty foot intervals with a few having forty foot intervals. Ground line profiles were plotted from these maps and surveys and the profile grade studies were established from this data. Earthwork quantities were calculated by using the average end area method.

Alternate No. 1

Alternate No. 1 alignment begins on the present Federal Aid Secondary Highway No. 416 in the vicinity of the South Billings Bridge across the Yellowstone River. This terminus is common with Alternate No. 2. From this point, it utilizes the present County Road for about 16 miles up the Blue Creek Valley and across the divide into the Pryor Creek Valley where it connects with the Pryor Creek Road approximately 8 miles south of U.S. Highway 87 and 212. It then turns south and follows the existing Pryor Creek Road for approximately 7.8 miles. Near the mouth of Hay Creek, it swings southeasterly on new alignment and begins its ascent up Hay Creek to the dry land plateau. Traversing the dry land south toward the Pryor Mountains, Alternate No. 1 intersects the proposed alignment of the Indian Service Road from St. Xavier to Pryor. From this point to Muddy Creek a common alignment can be utilized for both roadways, that is for the Billings-Bighorn Lake road and the St. Xavier-Pryor Road. It then turns east across Hay Creek and the divide north of the existing trail to Dry Head Creek. It then crosses the East Fork of Pryor Creek some two miles north of the old Will James Ranch and continues east on approximately the same alignment as the existing ranch trail to the Lande Summer Ranch. At this location, the Bureau of Indian Affairs had originally proposed that the Pryor-St. Xavier road turn northeast down Beauvais Creek. Contingent upon the construction of Alternate 1, and in order to take advantage of the common alignment section, they now plan to continue along the Alternate No. 1 alignment to a location between Point and Muddy Creeks before swinging northeast. The new

alignment is shown on Figure 2. This would make the joint usage section 14.9 miles long. Alternate No. 1 then continues eastward crossing Scott Creek, Buster Creek, Horse Coulee and Point Creek to a location between Point and Muddy Creeks before turning south. It then traverses up the drainage to its terminus on the proposed National Park Service Road. This terminus was selected because of ease of construction and because the National Park Service and the Crow Indians felt it was the best location.

Between Muddy Creek and the National Park Service Road both Alternates 1 and 2 cross areas which are known to contain fields of Indian Archeological importance. The extent of these fields is not known but the Crow Indian Tribe would oppose disturbing them with highway construction and if they are extensive, some major realignment during design may be necessary.

Alternate No. 2

Alternate No. 2 begins on the present Federal Aid Secondary Highway No. 416 just south of the Yellowstone River, as does Alternate No. 1. It also follows the existing Blue Creek Road to its junction with the Pryor Creek Road. Alternate No. 2 then crosses Pryor Creek just east of the Pryor Road junction and follows the East Wets Creek drainage on new alignment as it climbs over the divide, and down into the East Fork Creek drainage. It then continues east across lowlands and dry farm land and crosses the divide into the Woody Creek drainage where it intersects the existing southerly access road used by the Scott Ranch. At this point Alternate No. 2 turns southeast and generally follows the existing Scott Ranch Road until it crosses Beauvais Creek. It then traverses rol-

ling terrain and crosses Horse Coulee, Point and Muddy Creeks where it intersects the Willcutt Ranch Road which it follows to the south. It then crosses Grapevine Creek and terminates on the proposed National Park Service Road about 3 miles northeast of the Alternate 1 terminus. The road eneded here because of lower construction costs and because the grade followed the ground contours for better vertical alignment. This end location was acceptable to the Bureau fo Indian Affairs and the Crow Tribe.

Other Alternates Considered

Several other routes were studied which are not included in detail in this report. They are Alternates 3 through 9 and are shown on Figure 2A.

Alternates No. 3 & 4

These two Alternates followed the same alignment as Alternate No. 1 to the crossing of the East Fork of Pryor Creek north of the Old Will James Ranch. They then turned south and made their ascent up the East Fork of Pryor Creek. Alternate 3 turned east before crossing the divide, staying on the north slope. Alternate 4 crossed the divide at the head of the East Fork of Pryor Creek and traversed the south slope. Both of these routes had their terminus with the proposed National Park Service Road near Hoodoo Creek. Although these routes had fewer miles of new construction, their adverse grades, anticipated snow cover and higher construction costs ruled them out for further consideration.

Alternate No. 5

This route followed the Pryor Creek Road and then turned southeast up the East Fork of Pryor Creek, closely following the existing ranch road until it intersected Alternate No. 1. It then followed the alignment

of Alternate No. 1 until it crossed the Middle Fork of Buster Creek where it turned south up and over the divide to its terminus on the proposed National Park Service Road near Hoodoo Creek. No further study of this Alternate was made because it crossed considerable valuable hay land and because the Crow Tribe objected to the route.

Alternates No. 6 & 7

These were variations of Alternates No. 1 and No. 2. They departed from the present alignments between Point and Muddy Creeks. Alternate No. 6 traversed the area to the north of Grapevine Creek and Alternate No. 7 followed Grapevine Creek to their common terminus, on the National Park Service Road near the afterbay. They were abandoned mainly because they provide routes roughly parallel to the National Park Service road and this was not considered economically justifiable.

Alternate No. 8

An alignment which could have been used with either Alternate No. 1 or No. 2 was investigated. This route would begin at the intersection of the Blue Creek and Pryor Creek Roads and follow the Pryor Creek Valley northerly to Interstate 90. This route was discarded because it created ten miles of out of direction travel for Billings to Big Horn Lake traffic.

Alternate No. 9

Preliminary study was devoted to this route which was proposed in the agreement and was to begin at Interstate 90 about 15 miles east of Billings and extended south and southeasterly to end near Yellowtail Dam. This Alternate would require the construction of an interchange at I-90 and was also costly due to the rough terrain it crossed. Montana State

Highway and Bureau of Public Roads Engineers reviewed the preliminary investigations and it was decided to abandon further study of this route in favor of the present Alternate No. 2.

Geometrics

To properly evaluate highway locations, comparisons of geometric features are useful. Table 1 lists the alternates studied and their corresponding geometric data.

Derivation of the data was computed as follows:

$$\text{Average Grade} = \frac{\text{Total Elevation Rise \& Fall}}{\text{Total Alternate Length}}$$

$$\text{Percent of Curvature} = \frac{\text{Total Length of Curves} + \frac{1}{2}\text{ Total Length of Spiral}}{\text{Total Length of Alternate}} \times (100)$$

$$\text{Average Degree of Curvature} = \frac{\text{Sum of (Degree of Curve) X (Length of Curve)} + \text{Sum of } (\frac{1}{2}\text{ Degree of Curve) X Length of Spiral}}{\text{Total Length of Curves} + \frac{1}{2}\text{ Total Length of Spiral}}$$

Total Horizontal Deflection = Sum of Curve Delta Angles

GEOMETRIC FEATURES

ON NEW CONSTRUCTION ONLY

ITEM	ALTERNATE #1	ALTNERATE #2
Length - New Construction (Miles)	29.1	34.5
Length - (Existing Alignment)		
Blue Creek Road (Miles)	16.0	16.0
Pryor Creek Road (Miles)	7.8	0.0
Total Length (Miles)	52.9	50.5
Average Grade	2.49%	2.53%
Maximum Grade	5.0%	5.0%
Percent of Curvature	34.11%	45.06%
Average Degree of Curvature	1.51°	1.41°
Maximum Degree of Curvature	2° 30'	2° 00'
Total Horizontal Deflection	902° 30'	1132° 30'
Grades of 5% (Miles)	3.2	2.9
Maximum Elevation Attained	5050	4250

Table 1

GEOLOGY

Purpose and Scope

A geological study of the area was made to provide a basis for evaluating the preliminary alternate locations being considered. It was done to determine the areas which may affect highway design and to provide some criteria for judging the probable stability of slopes and the general nature of the foundation materials. Investigations reported in the U. S. Geological Survey Bulletins 856 and 822-A and Water Supply Paper 599 were the basis for the geologic map Figure 9. A field reconnaissance over the area being considered supplemented the published material. This was largely a visual evaluation of soils and rock exposures under fairly moist ground conditions with some snow in the higher mountains. The scope of the investigation precluded drilling, laboratory testing of samples and the study of areas inaccessible to vehicular travel. A more detailed investigation should be made after the general route selection has been made.

Geography

The alternate routes under study lie within Yellowstone and Big Horn Counties and are largely within the Crow Indian Reservation. The ground elevations range from about 3,400 feet above sea level, along Pryor Creek in the north, to a maximum elevation of about 4,250 feet on Alternate No. 2 and 5,150 feet on Alternate No. 1, at their southern termini. The many small streams originating on the divide are entrenched in deep narrow canyons in their upper reaches. There is also a general erosional slope to the northeast that is evident by the elevations of

the ridges and benchlands. This slope has been attributed to an early course of the Clark Fork of Yellowstone River through Pryor Gap. The position of present stream courses and the elevation of land surfaces has been modified from the general slopes by uplifts, domes and faults. The principal stream is Pryor Creek which follows a northerly course to the Yellowstone River at Huntley. The eastern part of the study area and that part south of the high divide mentioned are drained by tributaries of the Bighorn River.

The "rusty" beds, sandstone exposures and varicolored clays exposed in the southern and southwestern part of the area provide interesting views. Sparse growth of coniferous trees and juniper are usually found in strips along the sandstone outcroppings. Cottonwoods and box elders are common in the valleys near streams. The density of grasses and shrubs varies with elevation and soil types. The area provides pasture and some hayland for cattle. Stockwater ponds are fairly numerous. Much of the rather uniform sloping benchlands in the western part of the area is devoted to dry land grain farming.

Geologic History

The sedimentary rocks exposed in the study area are the product of marine deposition from the early Carboniferous system to the Upper Cretaceous period. The total thickness of these deposits is considered to be about 5,000 feet. The oldest rock exposed is the Madison limestone, which caps the Grapevine Dome area near Yellowtail Dam on the Bighorn River. The Telegraph Creek formation which is skirted in the northeast part of the study area is the most recent rock outcrops. The principal formations are of the Colorado shale group which has a thick-

ness of over 2,000 feet. The five formations of the Colorado group are generally dark marine shales interspersed with varying amounts of clay, thin sandstones and bentonite. The flooding and recession of the seas during the periods of deposition and intermediate erosion created local variations in thickness, composition and appearance of the sediments. The uplift which formed the Rocky Mountains was in progress during some of the periods of deposition. The uplift of the Big Horn and Pryor Mountains created a general northward dip to the sedimentary deposits. Other more local structural changes such as the domes, uplifts and faults greatly modified the general dip of the strata. The varying erodibility of the exposed sediments has resulted in rather sharp breaks in relief above the gentler sloping valley bottoms. Sandstones are usually the capping or rimming beds protecting the underlying shale.

The General Geologic Map, Figure 9, shows the approximate exposures of the sedimentary rocks and shales with respect to the alternate road locations. Because of reproduction limitations, the 16 formations have been grouped into half that number. The letter symbols may aid in visualizing the extent of a particular formation in a group. A tabular composite geologic section, shown on Table 2, provides a brief description of the general characteristics of the formations.

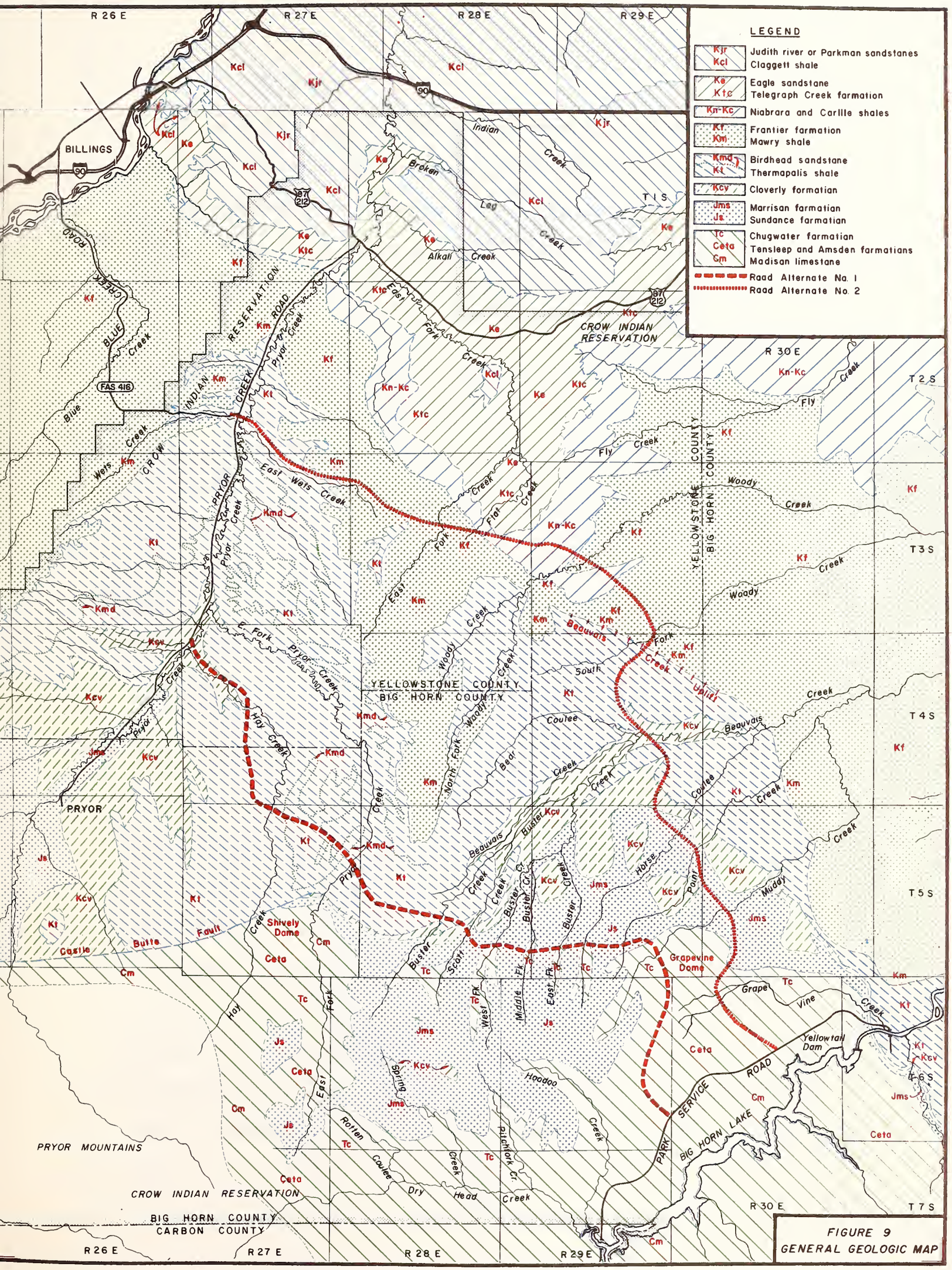
Terrace gravels of the tertiary period have been identified on some of the benchlands and also appear near Pryor Creek. More recent alluvium is found in some of the valleys. Figure 10 is a reproduction of the map of terraces and alluvium as given in U.S.G.S. Bulletin 856.

The soils in the northern two thirds of the area are chiefly clays resulting from erosion of the marine shales of the Colorado group.

GEOLOGIC SECTIONS

SYSTEM	SERIES	GROUP, FORMATION & MEMBER	THICKNESS	CHARACTER	MAP SYMBOL FIGURE 9
Cretaceous	Upper Cretaceous	Montana Group — Judith River or Parkman sandstone	280-350 ±	Essentially equivalent massive yellow sandstone with interbedded light-colored clays	(Kjr)
		Claggett shale	425-650	Dark marine shale with some sandstone & sandy shale in this area	(Kel)
		Eagle sandstone	100-225	Locally 3 sandstones separated by 2 shales of about equal thickness	(Ke)
		Telegraph Creek formation	320 ±	Yellow sandy shale parted in the middle by a thin concretionary, rim forming sandstone (Elk Basin sandstone)	(Kte)
		Niobrara shale	400 ±	Blue limy shale, weathering yellow	(Kn)
		Colorado Group — Carlile shale	425	Dark marine shale containing fossiliferous concretions, layers of limy shale & bentonite beds	(Kc)
		Frontier formation	400 ±	Dark marine shale containing beds of bentonite. Locally contains sandstone & sandy shales in upper members	(Kf)
		Mowry shale	200-300	Hard siliceous shale with some bentonite beds. Contains prominent sandy shales which cap some ridges near Beauvais and Woody Creeks	(Km)
		Thermopolis shale	525-800	Basal unit of dark shale, middle unit of ferruginous shales & bentonite, rim-forming Birdhead sandstone (Kmd) & an upper unit of gray sandy shales	(Kt)
	Lower Cretaceous	Cloverly formation	320-425	Basal conglomeratic sandstone, middle member of variegated clays, upper member of sandy shales & sandstone	(Kcv)
Jurassic	Upper Jurassic	Morrison formation	00-400	Maroon or variegated clays; some sandstone & yellow sandy shale near base	(Jms)
		Sundance formation	400-680	White limestone overlain by reddish sandy shale & greenish clay interbedded with brown sandstone	(Js)
Triassic & Carboniferous		Chugwater	500-655	Brilliant dark-red sandstone, sandy shales, local gypsum beds & a thin basal limestone	(Te)
Carboniferous	Pennsylvanian	Tensleep sandstone	45- 75	Course yellowish to white cross-bedded sandstone	(Ceta)
		Amsden formation	155-365	Red shale; thin red, white or purple limestones; limy shales and sandstones	(Ceta)
	Mississippian	Madison limestone	1,000 ±	Massive light gray to white limestone	(Cm)

TABLE 2


LEGEND
Kjr Kcl Judith river or Parkman sandstanes Claggett shale
Ke Ktc Eagle sandstane Telegraph Creek formation
Kn-Kc Niabrara and Carlile shales
Kf Km Frantier formation Mawry shale
Kmd Kt Birdhead sandstane Thermapalis shale
Kcv Cloverly formation
Jms Js Marrisan formation Sundance formation
Tc Ceta Cm Chugwater formation Tensleep and Amsden formations Madisan limestone
Road Alternate No. 1
Road Alternate No. 2
R 26 E
R 27 E
R 28 E
R 29 E
R 30 E
T 1 S
T 2 S
T 3 S
T 4 S
T 5 S
T 6 S
T 7 S
BILLINGS
CROW INDIAN RESERVATION
YELLOWSTONE COUNTY
BIG HORN COUNTY
CARBON COUNTY
PRYOR
PRYOR MOUNTAINS
Indian Creek
Broken Leg Creek
Alkali Creek
Blue Creek
Wets Creek
East Wets Creek
Pryor Creek
Fly Creek
Woody Creek
Beauvais Creek
Coulee Creek
Bear Creek
Buster Creek
Horse Paint Creek
Muddy Creek
Grapevine Dome
Shively Dome
Yellowtail Dam
BIG HORN LAKE
PARK SERVICE ROAD
Hoodoo Creek
Rotten Coulee
Dry Head Creek
Pitchfork Cr.
Spring Creek
Hay Creek
Scott Fk
West Fk
Middle Fk
East Fk
Castle Butte Fault
FAS 416
90
97
212
FIGURE 9
GENERAL GEOLOGIC MAP

These formations contain bentonite beds as well as sandstones. Soils on the benchlands are thin and contain a larger sand fraction. The debris slopes to the coulees and valleys are generally steep and may be susceptible to settlement under high fills. The upper soils in the valleys are clays. Some gravel is apparent in the Pryor Creek valley and the terraces to the west.

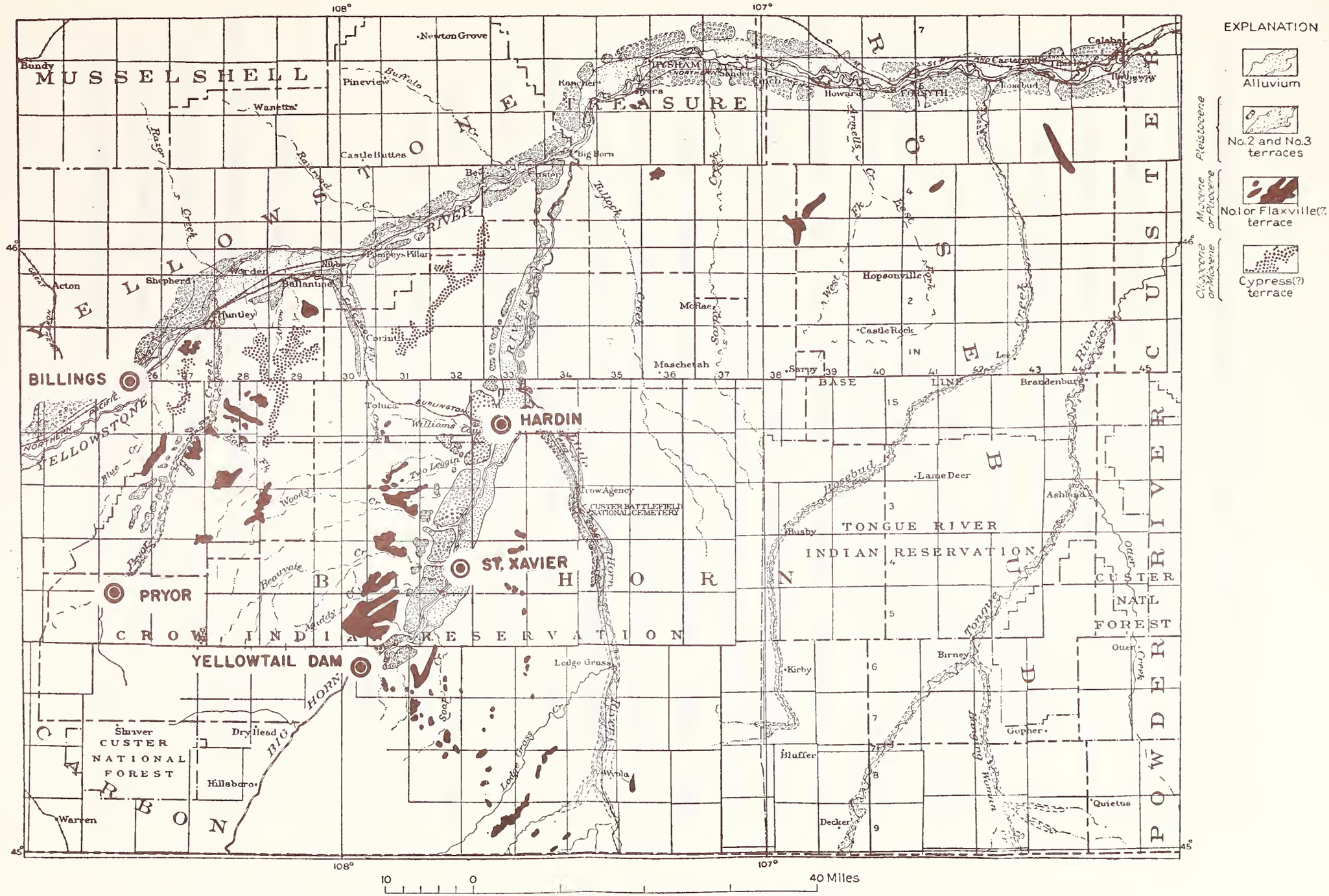
The soils in the southern part of the area were derived from the earlier formations which are chiefly sandstones with some sandy shale. The Chugwater formation is reported to contain some thick local beds of gypsum. These gypsum beds were not seen in the geologic reconnaissance. The steep surface slopes are conducive to a thin soil cover of sandy soil.

The uplifts, faults and domes have created some sharp contrasts in appearance and texture of soils within short distances. Where topography permits, slight changes in road location may be desirable to obtain more favorable soil texture or angle of the underlying beds.

Effects of Geology on Engineering Design

The geologic reconnaissance was largely a surface examination along the general location of the alternate routes. No drilling or laboratory testing was involved. The reconnaissance is believed adequate to evaluate the relative conditions of the locations considered. Prior to final design, detailed investigations, including drilling and laboratory testing, should be undertaken. Where clays dominate, some problems of subsurface drainage and consolidation of high fills are likely.

The interbedding of shale, clay and sandstone, which is characteristic of the Colorado group, is conducive to undercutting where more than one segment is cut. The Cloverly and underlying formations are



MAP SHOWING EXTENT OF TERRACES AND ALLUVIUM IN THE CROW INDIAN RESERVATION AND ADJACENT AREAS.

FIG. 10

generally sandier although some shales are present. Cut and fill slope criteria for "earth" as given in Standard Sheet No. 31 of "Field and Office Standards", as published by Montana State Highway Commission, for rolling terrain, is considered applicable for both Route Alternates. The "preferred" earth fill slopes given for Secondary Road Design have been used in preliminary design on all routes.

Geologic Evaluation of Alternate Routes No. 1 and No. 2

A brief description of the geology as it may bear on road construction follows for Alternate Routes No. 1 and No. 2. To a large degree, the comments are based on published reports. The field reconnaissance was made with a four-wheel drive vehicle as near the routes as topography would permit. Snow in the higher elevations may have obscured some features. This report provides a relative appraisal on the basis of the observed and reported soil and formation characteristics.

Although the two alternate route locations are common for the first few miles, the Route numbers 1 and number 2 are used to designate the location from their connection with the existing highway (Pryor Creek Road) to a connection with the proposed National Park Service highway near Yellowtail Dam. The stationing or mileages used in this discussion are approximate.

Alternate No. 1

The new alignment begins at the Pryor Creek Road about eight miles south of the Blue Creek Road junction and about fifteen miles south of its junction with U. S. Highway 87. It follows a southerly course for about ten miles toward the Shively Hill Dome. It then swings eastward for about 14 miles along the northerly side of a prominent ridge

toward the Grapevine Dome. Enroute it crosses the headwater drainage of a number of tributaries of Beauvais and Buster Creeks. It then follows a southerly route for about 6 miles to its junction with the proposed National Park Road about seven miles west of Yellowtail Dam.

The gravels and silts of the Pryor Creek bottom overlay the partially exposed sandstones of the upper Cloverly formation (Kev). Thermopolis shales (Kt) and soils derived from it are encountered soon after leaving Pryor Creek and continue to about Station 528. The soils are clays with varying sand fractions. The benchlands are dry farmed where topography permits. Grain stubble indicates productive soil. A few pebbles and dense angular rocks of limestone noted in some of the fields and ravines are evidently remnants of the early planing of the benchlands. The Thermopolis shale is reported to contain some bentonite beds in the middle member although no exposure or readily evident bentonitic soils were observed. The preliminary road profile shows many short fills of up to 30 feet in the ravines and cuts of up to 60 feet in the separating ridges in the first 6 miles. Between about Station 397 near the crossing of Hay Creek, and about Station 503, several fills of about 55 feet over small tributaries of Hay Creek would be required. Selective placement of fill material may be necessary to avoid settlement and heave problems.

Shortly after crossing Hay Creek, the route passes through the sharply northward dipping beds and the faults at the north edge of the Shively Hill Dome. The colorful sandstones, shales and limestones indicate the Sundance, Morrison and Cloverly formations will be encountered. Much of the soil is a reddish brown. An exposure of a dark

bentonitic shale which was noted along the East Fork of Pryor Creek probably lies to the north of the route. The fill over East Pryor Creek at Station 580 will be about 50 feet and subdrains may be needed in the dark clays of the Thermopolis shale in that vicinity. A number of deep cuts and fills would then be required as the route passes over a series of ridges to reach the headwaters of Beauvais Creek. The Thermopolis shale contains many sandstone members and better drainage and compaction is expected in this section.

A long fill with a maximum height of 110 feet is considered for the crossing of Beauvais Creek near Station 660. The adjacent cuts will probably contain some sandstone and clay soils containing some sands dominate. In the vicinity of Scott Creek, the steeply northward dipping beds of the Cloverly (Kev) and Morrison (Jms) formations are crossed and the soil is sandier. From the crossing of Scott Creek to about Station 1280, the Sundance (Js) formation prevails except for short reaches to Chugwater (Tc) near the major stream channels. The Sundance is largely composed of sandstones and the more resistant members form the caps on the ridges separating the streams. The red sandstones and sandy shales of the Chugwater make colorful views. The fill at Horse Coulee is as much as 120 feet but should offer no particular problem of stability. The shorter fill at Point Creek is about 90 feet in depth.

The Chugwater formation is exposed where the Tensleep (Ceta) sandstone outcrops on the west side of the Grapevine Dome. The Tensleep sandstone is a fairly pervious formation with a thickness of 45 to 75 feet. It overlies the much thicker Amsden formation which is given the same "Ceta" symbol on the geologic map. These two formations continue

to the junction with the proposed National Park Service Road. This road is in the Amsden formation which is largely varigated sandstone or limy shale where fill height will not likely present serious problems.

Alternate No. 2

This alternate location leaves the Blue Creek Road just west of the Pryor Creek Road about 8 miles south of U. S. Highway 87. It then follows a general southeasterly direction to the intersection with the National Park Service Road. Enroute, it follows the East Fork of Wets Creek to a prominent ridge. After leaving the ridge, it crosses the headwater areas of East Fork Creek and Woody Creek. A more southerly direction is followed after crossing the South Fork of Woody Creek at about Station 900. After crossing Beauvais, Point and Muddy Creeks, it passes along the east side of Grapevine Dome, crosses Grapevine Creek and joins the National Park Service Road.

The soils and rock along the first five miles are of the Thermopolis shale formation. Gravels and alluvium are located in the Pryor Creek valley and a few gravel remnants, perhaps of Pleistocene origin, are located near the East Fork of Wets Creek. The Thermopolis shale soils are clays with a considerable sandy fraction in the upper members of that formation. Mowry shale (Km) forms the more weather resistant cap at the ridge and due to the northeasterly dip of that formation, continues for about three miles. The soils of the Mowry formation contain a fair amount of sand and tilled wheatland indicates the soil is quite friable. The hogback ridges which are followed on the descent to East Fork Creek have some sandstone outcrops. The cut of about 60 feet in leaving the ridge should be in quite stable shale and sandstones. The bottom land soils of East

Fork Creek and Flat Creek are somewhat heavier clays with no evidence of bentonite noted in the brief reconnaissance. The Frontier formation and related soils are evident from about Station 370 to 450. They contain some sand and appear to offer no road problem where drainage is adequate. The Carlile (Kc) and Niobrara (Kn) shales generally prevail to about Station 820 except for a recurrence of the Frontier in the Woody Creek Valley near Station 735. The location selected follows a number of the low ridges between minor draws leading to Woody Creek. Drainage of the Carlile and Niobrara shale soils appear to be good. The route returns to the Frontier formation which prevails to the crossing of the South Fork of Woody Creek at about Station 915. The soils through the gap in Beauvais Creek uplift near that stream show a decided clay gumbo character. Thermopolis shale soils, of somewhat denser clays than those of the first four miles of this route, are then found to about Station 1058. Sandier soils of the Cloverly formation (Kcv) and denser alluvial soils of the Beauvais Creek Valley extend to about Station 1190 where the sandier upper member of the Thermopolis shale appears. A return to the Cloverly occurs near Point Creek at about Station 1373 and prevails to about Station 1530. This is followed by about 1½ miles of varicolored soft shales and sandstones of the Morrison formation (Jms) that weather to a sandy clay. The Sundance (Js) and Chugwater (Tc) formations appear on the north and east side of Grapevine Dome. The Tensleep and Amsden formation (Ceta) then continue to the junction with the proposed National Park Service Road. There are a number of cuts up to about 40 feet deep and fills of 50 to 90 feet in the last four miles. The cuts would be in sandstones or limy shales. No problem of stability of cuts or fills is anticipated in this section.

Comparison of Geology on Alternate Routes No. 1 and No. 2

In general, the geologic formations encountered on Alternate No. 1 are slightly more stable for road construction than those along Alternate No. 2. The deeper cuts on Alternate No. 1 may be expected to involve more excavation in shales and sandstones. Many fills on Alternate No. 1 are also high which could present greater problems of consolidation. The infiltration of water into the rather sandy strata of the Cloverly and earlier formations may result in seasonal or perennial springs. Alternate No. 1 would appear to be more susceptible to this condition. In partial offset of these unfavorable factors, it should be mentioned that Alternate No. 2 traverses formations where bentonitic material is likely to be more prevalent. Another offsetting factor in favor of Alternate No. 1 is the likelihood of high unit runoff from intense summer rains on streams such as Woody and Beauvais Creeks. Considering the net probable effect of the above factors, a slight preference is felt, from a strict geological standpoint, for Alternate No. 1.

Since the scenic features are to receive consideration in the selection of a road where recreational travel accounts for much of the traffic, it should be mentioned that Alternate No. 1 will provide more distant views and more colorful contrasts of formations.

Geologic Evaluations of Existing Roads

Alternate No. 1 makes use of the present Pryor Creek road for a distance of about 7.8 miles. The road follows the valley bottom on a topsoil of silty clay, with a few short reaches in the gravelly soils at the valley edge. Recent alluvium consisting of some gravel underlies the top soil. Although the present asphalt pavement shows some evidence

of heave or settlement, it is probably due to non-selective use of available subgrade material. The underlying formation is the Thermopolis and some sandstone outcrops are visible at the valley edge and in the creek bottom.

The present Blue Creek Road provides a connection from the Pryor Creek Road to Billings and the Interstate Highway System for both Alternates 1 and 2. The greater part of the route is through the Mowry Shale. The soils are clays containing some sand and appear to be quite free of bentonitic characteristics.

HYDRAULICS AND DRAINAGE

Stream Flow Study

Both Alternates No. 1 and No. 2 cross many natural drainage channels. Considerable variation in peak runoff rates can be expected because of differences in infiltration rates between clay and sandy soils. Slope of the terrain and vegetation can be expected to have a lesser effect. Cultivation may have an appreciable effect on small drainage areas, as would upstream stock water ponds.

Long-term stream flow records of Pryor Creek should be a satisfactory guide to flows of that stream within the area concerned. Peak flow records of 15 years are available for Wets Creek (8.14 sq. mi.) and West Buckeye Creek (1.54 sq. mi.). These two tributaries of Pryor Creek have experienced peak flows which are probably rarer than the length of record would indicate. Records of Soap Creek near St. Xavier and Lodgegrass Creek, near the City of Lodge Grass, each cover a period of about 30 years. One or more years of record are available for Dryhead, Beauvais, Bluewater and a few other streams. Comparison of flow records with geological maps indicate soil types are highly significant. Although snowmelt is the cause of some peaks, rain-caused peaks apparently are the highest.

Stream flow records of 9 or more years each were analyzed for flood frequency by the Gumbel method. The 50-year and 25-year recurrence intervals for these stations are shown on a log-log plot of discharge versus drainage area shown on Figure 11. A USGS open-file report (1967) on flood frequency was the basis of the runoff curve. Geographic area

"M" from this report covers the study area. Water Supply Paper 1679 shows the 50-year peak is about 1.3 times the 25-year peak for drainages of more than 10 square miles in this geographic area. The 25-year Area M curve was multiplied by 1.3 to arrive at an approximate 50-year curve. Peaks of record for Blue, Beauvais and Dryhead Creeks were also plotted.

It is fairly evident that runoff from the Colorado Shale group is substantially higher than the earlier and later geologic formations in the area. The records of Soap Creek and Lodgegrass Creek are indicative of the contrast. Curves for 25-year and 50-year peaks for clay soil areas were based on recurrences on West Buckeye, Wets, Bluewater and Soap Creeks, The Area M curves were considered applicable to the rather sandy soil areas. As the record of Pryor Creek near Billings covers the years 1912-24 and 1938-68, it was considered the best basis for peak runoff on the mainstem of that stream. The variation with drainage area on that stream was considered to be that of the region 8 curve of U.S.G.S. Water Supply Paper 1679.

For drainage areas of less than two square miles, the rational formula, $Q = CiA$, is believed to be more suitable than the above curves. Rainfall intensities as given in U. S. Weather Bureau Technical Paper No. 40 are suggested.

The hourly rates (i) for various durations are:

Duration	50-Year	25-Year
1 hour	1.6 Inches	1.3 Inches
30 Minutes	2.3 Inches	2.1 Inches
15 Minutes	3.3 Inches	3.0 Inches

The peak runoff of 840 cfs on West Buckeye Creek on July 18, 1969, indicates a "C" factor of 0.3 for clay soil and fairly steep slopes. A minimum factor of 0.15 is suggested.

Peak flows for 25-year and 50-year recurrences are shown on the basis curves for drainage areas of over 2 square miles. It may be helpful to provide some data on approximate corrugated pipe size required for each frequency for some of the larger streams where corrugated metal pipe is assumed for use. A headwater to depth ratio of 1.5 was used in the examples given for corrugated metal pipe drainage structures.

DRAINAGE SUMMARY

Alternate No. 1 - Lower Hay Creek - 23 sq. miles - Sandy Soil Curve

25 yr.	860 cfs.	108" dia. Pipe
50 yr.	1,100 cfs.	120" dia. Pipe

Alternate No. 1 - East Fork Pryor Creek - 36 sq. mi. - Sandy Soil Curve

25 yr.	1,080 cfs.	120" dia. Pipe
50 yr.	1,400 cfs.	132" dia. Pipe

Alternate No. 1 - Pryor Creek - 240 sq. mi. - Main Stem Pryor Creek Curve

25 yr.	2,230 cfs.	Bridge
50 yr.	3,280 cfs.	Bridge

Alternate No. 2 - Pryor Creek - 390 sq. mi. - Main Stem Pryor Creek Curve

25 yr.	2,840 cfs.	Bridge
50 yr.	4,150 cfs.	Bridge

Alternate No. 2 - East Fork Creek - 14.4 sq. mi. - Clay Soil

25 yr.	1,450 cfs.	132" dia. Pipe
50 yr.	1,900 cfs.	144" dia. Pipe

Alternate No. 2 - Woody Creek - 27 sq. mi. - Clay Soil

25 yr.	2,000 cfs.	150" dia. Pipe
50 yr.	2,600 cfs.	168" dia. Pipe

Alternate No. 2 - Beauvais Creek - 100 sq. mi. - Clay (80%) Sandy (20%)

25 yr.	3,300 cfs.	Bridge
50 yr.	4,200 cfs.	Bridge

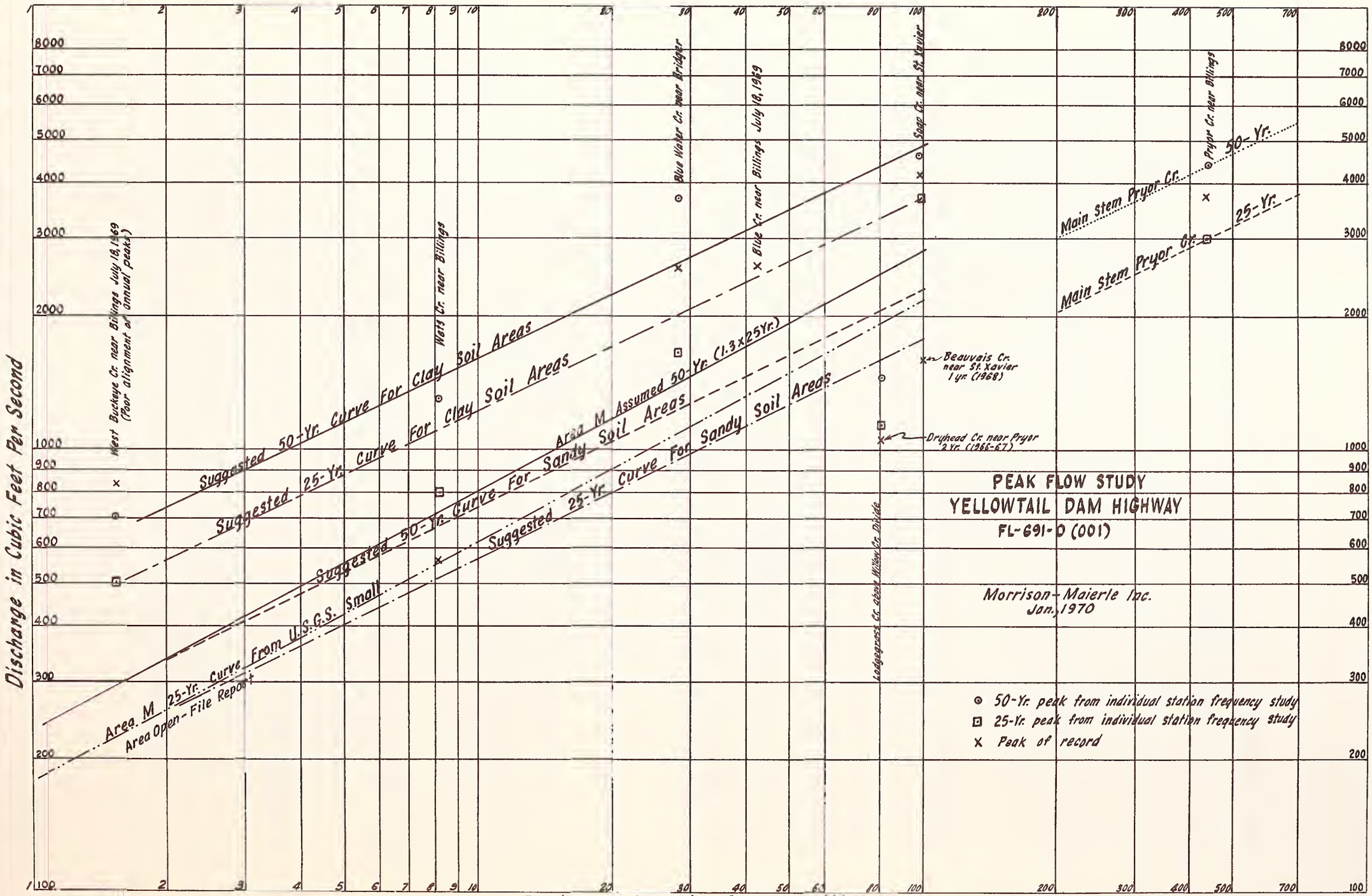

Discharge in Cubic Feet Per Second
Drainage Area in Square Miles
Suggested 50-Yr. Curve For Clay Soil Areas
Suggested 25-Yr. Curve For Clay Soil Areas
Area M Assumed 50-Yr. (1.3 x 25Yr.)
Suggested 50-Yr. Curve For Sandy Soil Areas
Suggested 25-Yr. Curve For Sandy Soil Areas
Area M 25-Yr. Curve From U.S.G.S. Small Area Open-File Report
West Buckeye Cr. near Billings July 18, 1969 (Poor alignment of annual peaks)
West Cr. near Billings
Blue Water Cr. near Bridger
Blue Cr. near Billings July 18, 1969
Soap Cr. near St. Xavier
Lodgegrass Cr. above Willow Cr. Divide
Main Stem Pryor Cr. 50-Yr.
Main Stem Pryor Cr. 25-Yr.
Pryor Cr. near Billings
Beauvais Cr. near St. Xavier 1 yr. (1968)
Dryhead Cr. near Pryor 2 Yr. (1966-67)
PEAK FLOW STUDY
YELLOWTAIL DAM HIGHWAY
FL-691-D (001)
Morrison-Maierle Inc.
Jan. 1970
50-Yr. peak from individual station frequency study
25-Yr. peak from individual station frequency study
Peak of record

FIG. 11

Preliminary Drainage Structure Design

The 25-year peak flow estimates were used for sizing of drainage structures at major stream crossings. The cost estimates include proposed bridges at the main stem Pryor Creek crossings for both Alternates No. 1 and No. 2 and Beauvais Creek on Alternate No. 2. For preliminary cost estimate purposes, the Pryor Creek and Beauvais Creek bridges have been assumed to be 90 feet in length and 38 feet wide. Costs are figured at $12.00 per square foot. Structural Plate culverts have been assumed for cost estimate purposes for all other major stream crossings. Size of culverts have been estimated on the basis of the discussion, flow curves and culvert size illustrations in the preceeding sub-section entitled, "Stream Flow Study."

A cost of $10,000 per mile was used for all minor drainage culverts in addition to the cost of major stream crossings as discussed in the paragraph above.

All drainage cost estimates include an allowance to cover such culvert incidentals as headwalls, select bedding material and culvert excavation.

Subsurface Drainage for Roadbed Stability

As stated in the "Geology" section, there are some areas along both Routes where infiltration of water into certain of the sandy strata results in seasonal or perennial springs. During final design for the route chosen, these conditions will have to be considered either by care in locating the roadway or by providing subsurface drainage facilities. Alternate No. 1 encounters more subsurface drainage areas than Alternate No. 2, but there are other other adverse conditions on Alternate No. 2, such as high surface runoff and bentonitic materials.

No attempt has been made to place a comparative cost for subsurface drains on either of the two alternates. Such costs as may be involved for subsurface drainage would be small in comparison to the overall cost estimate for each of the two alternates. A contingency for this purpose was included in the $10,000/Mile cost for small drainage culverts.

DESIGN STANDARDS AND CRITERIA

General Information

Design criteria for this study was based on standards for construction of Rural Highways. This policy is outlined in the pamphlet entitled, "Geometric Design Standards for Highways Other Than Freeways," as adopted by the American Association of State Highway Officials (AASHO) and the U.S. Department of Commerce, Bureau of Public Roads. The booklet, "A Proposed Program For Scenic Roads and Parkways" prepared by the U.S. Department of Commerce, along with the following books and publications were also used as design guides in preparing this report.

AASHO Publications

Policy on Geometric Design of Rural Highways

Road User Benefit Analysis for Highway Improvements

Highway Capacity Manual

MSHC Publications

Standard Specifications for Road and Bridge Construction

Field and Office Standards

Standard Drawings

Design Factors

1. Type of Terrain - Rolling
2. Design Speed - 60 mph
3. Traffic Lane width - 12 feet
4. Roadway Width - 34 feet

Typical Roadway Design

The typical section used in this study is shown on Figure 12. The pavement section consists of two 12-foot traffic lanes and two 5-foot shoulders based on future estimated traffic volumes. An estimated preliminary section depth of 2-feet was used.

The Geology section of this report describes the material through which this highway must be constructed. Cut and fill slope design was based on the "MSHC Office and Field Standards", sheet No. 31, for rolling terrain. The only exception was that the maximum cut slope for depths in excess of 20 feet was 2:1.

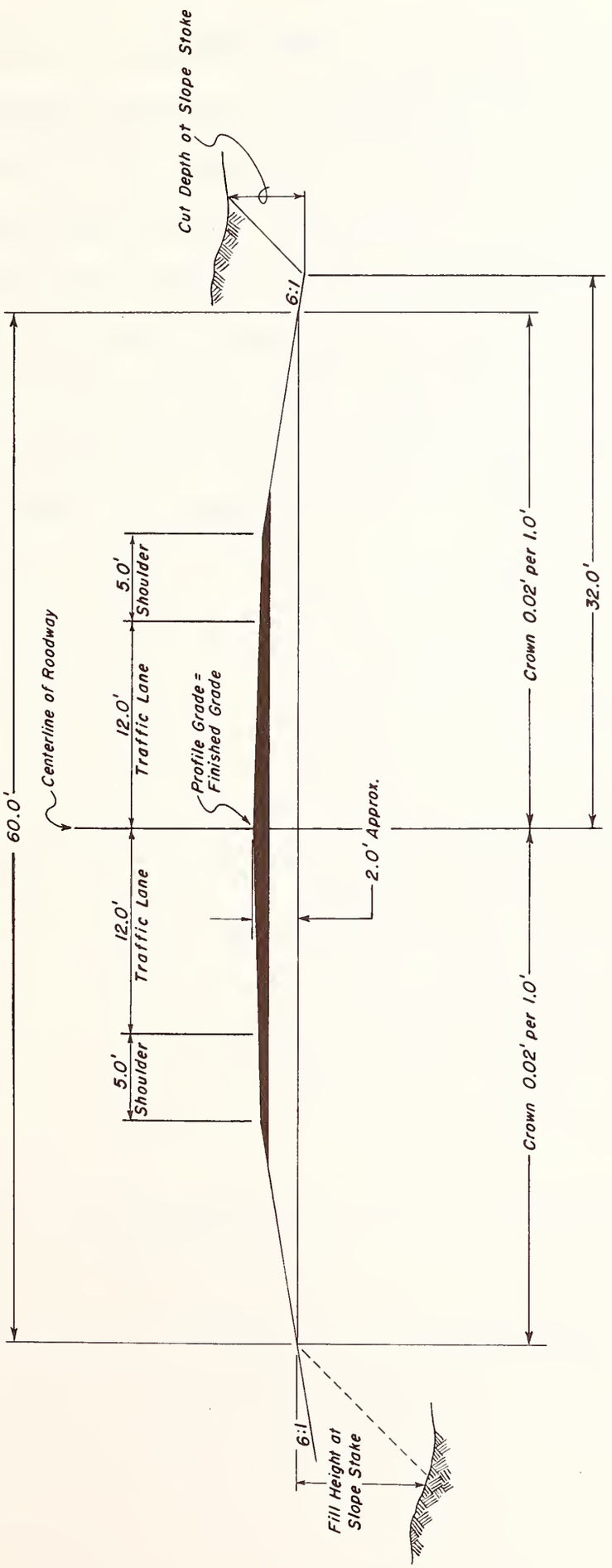
Excavated material will make suitable material for embankment construction for the fill slopes, provided that compaction and other construction methods are proper and adequate.

Spiral transitions will be required on all horizontal curves with a degree of curvature of $1^{o}30'$ and greater. The rate of superelevation will not exceed 0.06 of a foot per foot. Transition to and from full super will be provided for as prescribed in MSHC "Field and Office Standards", Sheet 20.

All new sections of the highway under this study have been designed for 60 mph Stopping Sight Distance and all longitudinal gradients have been maintained at 5% or less. In the section on "Geometrics and Location", gradient and curve data have been summarized in tabular form.

Standard swell factors from the MSHC "Office and Field Standard" were used to arrive at an earthwork balance. Undoubtedly these factors will be altered upon a more extensive geological survey prior to final design.

FIGURE 12



TYPICAL ROADWAY SECTION

It was assumed that the two existing roadways, Blue Creek and Pryor Creek, would be updated to conform to the typical section as shown for the new construction, Figure 12. Blue Creek, with its 24 foot roadway and Pryor Creek with its 18 foot roadway, would have to be widened and built up with superelevations and spirals added to all existing circular curves. It was assumed that an asphalt overlay will be provided for adequate pavement strength. Thus these existing roads can be brought up to 60 mph design standards except that Blue Creek will still have a maximum gradient of 9% which exceeds this design criteria.

ADDITIONAL CONSIDERATIONS

Social, Economic and Environmental Effects

Either Alternate No. 1 or Alternate No. 2 offers definite advantages to the communities and surrounding areas involved and to the road user when compared with the existing route between Billings and the Big Horn Lake National Recreation Area. Although the following remarks could in many cases be applied to either alternate, we feel that Alternate No. 1 is the most desirable and the comparisons made will be between Alternate No. 1 and the existing route.

A faster, shorter, safer and more efficient transportation route would be provided through the use of Alternate No. 1 between Billings and the Big Horn Lake vicinity. It would also be a benefit to traffic bound from Pryor to St. Xavier or from Pryor to the Big Horn Lake area. It should also benefit the general economic activity of the entire area. It would provide year-round access to the several ranching operations in the area. It is conceivable that this improved access may promote expansion of existing business operations or may make the area attractive to other types of business. It is not expected that the small amount of right-of-way required for the construction of this route would in any way disrupt existing ranch operations.

This alternate would not displace any families or businesses and no replacement housing programs will be required in this area.

Education will in no way be adversely effected. It could only benefit by the fact that the new route would provide a much better facility for transporting children to and from school.

Conservation is continually becoming a more important factor in the construction of highways. Completion of this route is not expected to adversely effect wild life or the general ecology of the area. Although no specific recommendations were made concerning erosion control, appropriate methods will be considered in the more detailed design phases.

It appears that either alternate would be a benefit from the standpoint of national defense, simply because it would provide a shorter route between Billings and Yellowtail Dam and would reduce travel time between these points in the event of a national emergency.

An important advantage of the recommended alternate is the aesthetic qualities which it possesses. It offers the traveler views of many interesting geological formations, as well as providing access to many historic land marks.

Right-of-Way and Access

The two alternates studied would, for the most part, traverse the same type of land as far as use and ownership are concerned. Although no detailed study of right-of-way acquisition has been made, it would appear to be somewhat complex because of the large number of ownerships and leases which will be encountered. Both alternates would traverse the Crow Indian Reservation with property being owned by the Crow Tribe, individual Indians and large non-Indian ranch operators with deeded and leased land holdings. Most of the land in the area is used for grazing purposes at the present time.

For those portions of Blue Creek and Pryor Creek Roads to be upgraded, the situation is relatively simple. In general, existing

right-of-way on Blue Creek Road should provide sufficient width to construct the necessary improvements. Pryor Creek Road would involve purchasing additional right-of-way width in certain areas.

Access into this area will be greatly improved using either Alternate. Alternate No. 1 provides probably the greatest overall improvement in access, serving approximately eight ranches as compared to two ranches served by Alternate No. 2. Roads into the area of study are nothing more than "dirt trails." Seasonal weather can virtually halt any access into or out of the area, even with vehicles equipped with 4-wheel drive.

No problems can be foreseen with property owners if the proper stock crossings and stockpasses are provided for continuity of the grazing land. This would have to be handled during Right-of-Way negotiations and no specific costs are included in the estimates for these items. They were considered and are covered by contingencies.

Utilities

The number of utilities encountered for both Alternates are minor. Alternates No. 1 and No. 2 would both require new construction over a fuel products line and would cross under two overhead power transmission lines. Alternate No. 2 would parallel another pipeline and power line for some distance. Careful design for construction should avoid any problems in these cases.

Local Service and Maintenance of Traffic

Maintenance of local service in the area of this study will not be a major construction problem. Stage construction will provide for

a continuation of travel with very little traffic interference. This can be accomplished by building the new construction first, and then upgrading Blue Creek and/or Pryor Creek Roads.

Maintenance of traffic is a very real expense in the construction of highways. Cost estimates must reflect the costs to the highway contractor for maintenance of passage and detours. This is especially true in the upgrading of Blue Creek and Pryor Creek Roads where the existing road and right-of-way would be utilized and the local traffic must have access through the construction area. Cost estimates used in this study have these extra expenses included in the cost per mile.

ECONOMIC ANALYSIS

General Information

An economic analysis was made to compare the two alternate alignments on an annual cost basis. This analysis includes all the items that can be evaluated in terms of cost. The Road User Operating Cost Analysis was made in accordance with the AASHO informational Report entitled "Road User Benefit Analysis for Highway Improvements", Part 1, Passenger Cars in Rural Areas.

Basis for Traffic Forecasts

The traffic forecasts were furnished by the Montana Highway Commission through their Planning Survey Department. They are based on a previous study by a consultant in which it was estimated that 660,000 visitations to the Bighorn Lake National Recreation Area would occur by 1970 and 1,815,000 by the year 2000. These visitations were expected to occur during a 100 day tourist season.

These figures were converted to average daily traffic (ADT) and assigned to the Alternate routes. Local recreation trips were assigned on the basis of population and distance and out-of-state visitations were assigned on the basis of probable routes that tourists might take.

The Bureau of Indian Affairs Road from Pryor to St. Xavier was estimated to carry an ADT of 280 cars in 1975 and 460 in 1990. This is not shown on the map.

Estimated average daily traffic for the years 1975 and 1995 is given on Figure 2 for each section of roadway. 1975 ADT is shown above the 1995 values thus: $\frac{585}{1140}$ On the joint usage section of Alternate 1

the traffic volumes shown do not include the Pryor-St. Xavier traffic.

The average annual daily traffic for the year 1985 was used in the Road User computations. It was calculated on a straight line proportion between 1975 ADT and 1995 ADT.

Basis for Construction Cost Estimates

Unit costs used in making these estimates were arrived at through a study of the "Tabulation of Low Bid Prices" for highway contracts, furnished by the Montana Highway Commission, on projects which were similar in nature to the study area. No adjustment was made for possible future construction cost increases.

Excavation, which includes water, rolling and haul, was computed at $0.40 per cubic yard. Surfacing costs, which include signing, seeding and fencing, were assigned a unit price of $40,000 per mile for new construction. Guard rail was figured on all embankment slopes over 15 feet in height. The unit price used per lineal foot was $4.50.

Small drainage culverts, 60" in diameter and under, were figured on a lump sum price of $10,000 per mile. The larger drainage structures were figured individually using the average unit bid prices per foot and then added to the appropriate alternate.

Although right-of-way and related items are not considered construction costs, they were included in the total cost picture. The amount of cultivated dry crop land crossed by either alternate is negligible. For the most part, the land usage is grazing. Estimated costs to secure right-of-way was figured using a strip of land 200 feet wide for the entire length of both alignments. A cost of $4,848 per mile was used.

The basic construction costs for upgrading Blue Creek and Pryor

Creek roads were estimated to be $43,225 per mile. This was calculated by using Montana State Highway Commission bid tabulations of construction projects that were similar in nature such as projects which required shoulder widening, new guard rail, asphalt surface overlay, etc.

Annual Cost Determinations

Annual Costs were computed by amortizing the capital improvement costs (cost of construction R/W, etc.) at 6% compound interest and using the following amortization periods:

Surfacing, Guardrail Fencing and Seeding----------20 years

Grading, Drainage and Structures----------40 years

Right-Of-Way----------50 years

Annual maintenance costs used were $3,000 per mile for Interstate and $1,000 per mile for primary and secondary roads. Tables 4 and 5 summarize the initial and annual costs for all the alternates presented.

Basis for Road User Operating Cost Estimates

In addition to initial construction costs, Annual Road User Costs were calculated. These costs are related to the number of vehicles using the facility and also are related to the features and type of roadway involved.

Road User Costs were determined using the formula:

$$A \times U \times L \times 365 \text{ days/year}$$

Where "A" is the adjusted ADT (average daily traffic - no. of vehicles)

Where "U" is the Cost Per Vehicle Mile

Where "L" is the alternate length in miles

The Road User Costs were evaluated for different conditions of operation on the various types of roadways. The referenced AASHO Report, referred to in "General Information", assigns individual vehicle operating

costs for the following: type of vehicle, area, type of highway, operation, surface, running speed, alignment and gradient class. The average grade for the total alternate length was used to determine the unit operating cost. An average annual daily traffic of 820 based on Alternate No. 2 volumes was assigned to each of the three routes used. This is the number of vehicles whose origins and destinations are expected to be Billings and Yellowtail Dam area. Running speeds, type of operation, and user costs per vehicle mile are shown in Table 3.

VEHICLE OPERATING COSTS

Roadway	Running Speed		Type of Operation		User Cost/Vehicle Mi.	
	Existing (mph)	Upgraded (mph)	Existing	Upgraded	Existing	Upgraded
Blue Creek (N½)	34	39	Normal	Normal	$0.1056	$0.1037
Blue Creek (S½)	36	41	Normal	Normal	0.1039	0.1023
Pryor Creek	36	43	Normal	Free	0.1039	0.0949
Alternate #1	--	43	--	Free	--	0.0949
Alternate #2	--	43	--	Free	--	0.0949
Interstate #90	50	--	Free	--	0.0936	--
Hardin-Ft. Smith (Mont. 313)	41	--	Free	--	0.0955	--

TABLE 3

Unit Vehicle Operating Costs used were those published in the AASHO Informational Report except that the unit price of gasoline was increased from 32 cents to 40 cents per gallon to reflect current prices in Montana.

Cost Summary and Conclusions

Economic data summarized on Tables 4 and 5 should not be the only criteria used in selecting an alternate. An important advantage of Alternate No. 1 is the previously discussed probability of a section of roadway being used jointly with the Bureau of Indian Affairs. This "joint usage" section is some 14.9 miles in length and has an initial construction cost of $2,322,820 and an annual cost of $169,800. The figures shown in parentheses on Tables 4 and 5 are the result of subtracting the "joint usage roadway" costs from the total cost of Alternate No. 1. They show that under these conditions, Alternate No. 1 is the most economical both for initial construction cost and for the total annual cost assuming that the Pryor to St. Xavier Indian Service Road would be constructed approximately as shown on Figure 2.

CONSTRUCTION COST COMPARISON

DESCRIPTION	Alternate No. 1	Alternate No. 2
(New Construction Only)		
Length	29.1 Miles	34.5 Miles
Grading (Earthwork)	$2,033,730	$1,374,330
Drainage (including bridges)	$ 429,000	$ 494,000
Surfacing (fencing, signing & seeding)	$1,164,000	$1,380,000
Guard Rail	$ 215,640	$ 134,550
Right-of-Way	$ 141,100	$ 167,300
SUBTOTAL	$3,983,470	$3,550,180
Contingencies & Engineering	$ 796,690	$ 710,040
TOTAL	$4,780,160	$4,260,220
	**(2,457,340)	
(Upgrade Existing Roads)		
Blue Creek Road (16.0 miles)	$ 691,620	$ 691,620
Contingencies & Engineering	$ 138,320	$ 138,320
SUBTOTAL	$ 829,940	$ 829,940
Pryor Creek Road (7.8 miles)	$ 337,170	---
Contingencies & Engineering	$ 67,430	---
SUBTOTAL	$ 404,600	
TOTAL	$1,234,540	$ 829,940
TOTAL CONSTRUCTION COST (New Construction plus upgrading of Existing Roads)	$6,014,700	$5,090,160
	**(3,691,880)	

** Cost of Alternate with 14.9 mile joint usage section excluded.

TABLE 4

ANNUAL COST COMPARISON

ROUTE	LENGTH (MILES)	RIGHT-OF-WAY & UTILITIES	GRADING & DRAINAGE	SURFACING& GUARD RAIL	TOTAL ANNUAL CONST.COST	ANNUAL MAINTE-NANCE COST	OPERATING COSTS	TOTAL ANNUAL COST
New Construction Only:								
Alternate 1	52.9	$8,950	$163,670	$120,280	$292,900 **(123,100)	$52,900	$1,570,730	$1,916.530 **(1,746,730)
Alternate 2	50.5	10,610	124,170	132,040	266,820	50,500	1,481,550	1,798,870
New Construction Plus Upgrading Existing Roads								
Alternate 1	52.9	10,060	163,670	227,910	401,640 **(231,840)	52,900	1,541,340	1,995,880 **(1,826,080)
Alternate 2	50.2	10,610	124,170	204,390	339,170	50,500	1,473,170	1,862,840
Existing Route I-90 & Mont. 313	88.2	---	---	---	---	*49,800	2,579,990	2,629,790

* 1/5 of Maintenance Cost (I-90) $600 Per Mi.
* 1/2 of Maintenance Cost (Mont.313) $500 Per Mi.
** Cost of Alternate with 14.9 mile joint usage section excluded

TABLE 5

MEETINGS AND CONFERENCES

Several conferences were held during the development of the study with the various agencies known to have an interest in this route study. The purpose was to obtain the views and positions of all these groups so that their needs could be considered in selecting the alternate alignment which would best satisfy the public needs and the requirements set forth in the Engineering Agreement. Many of the facts and opinions disclosed in these meetings were used to supplement the engineering studies. Listed below are the agencies attending, the dates, and location of those meetings. The first agency listed for each meeting is the prime one for which that particular conference was arranged. Representatives were also present from the other listed groups.

		Location	Date
1.	Crow Indian Tribe Bureau of Indian Affairs National Park Service Big Horn Econ. Development Montana State Highway Comm. Morrison-Maierle, Inc.	Crow Agency	April 23, 1970
2.	Big Horn County Commissioners City of Hardin Crow Indian Tribe Bureau of Indian Affairs Hardin Chamber of Comm. Montana State Highway Comm. Morrison-Maierle, Inc.	Hardin	May 4, 1970
3.	Big Horn Road Association Hardin Chamber of Commerce Billings Chamber of Commerce Sheridan, Wyo. Cham. of Comm. Lovell, Wyo. Cham. of Comm. National Park Service Big Horn Econ. Development Crow Tribal Attorney Montana State Highway Comm. Morrison-Maierle, Inc.	Hardin	May 19, 1970

		Location	Date
4.	Carbon County Commissioners Red Lodge Chamber of Comm. Highway 212 Association Soil Conservation Service Citizens of Edgar & Bridger Montana State Highway Comm. Morrison-Maierle, Inc.	Red Lodge	May 22, 1970
5.	Billings Chamber of Commerce (Transportation Committee) Morrison-Maierle, Inc.	Billings	June 3, 1970
6.	Yellowstone Co. Commisnrs. Montana State Highway Comm. Morrison-Maierle, Inc.	Billings	June 29, 1970
7.	U.S. Forest Service Morrison-Maierle, Inc.	Billings	July 21, 1970
8.	Crow Indian Tribe Bureau of Ind. Affairs National Park Service Crow Tribe Recre. Committee Tribal Attorney Morrison-Maierle, Inc.	Crow Agency	August 3, 1970

A number of variations to these alignments were discussed at the meetings, but it was the general consensus at the conclusion of all conferences that Alternate No. 1 had the greatest merit. All of the groups and agencies endorsed Alternate No. 1 with the exception of the Yellowstone County Commissioners. They felt that a route south from I-90 to Yellowtail Dam, similar to Alternate No. 9, would be more desirable for Billings to Bighorn Lake traffic. Our investigation showed that this route was longer, produced more out-of-direction travel and was more expensive than either Alternate No. 1 or Alternate No. 2.

The conferences contributed a very worthwhile meaning to the success of this study. They not only pointed out important aspects that had been previously unknown, but they also pointed out the background, needs, and interests of the local people. The Bureau of Indian Affairs has expressed

the opinion that the joint usage roadway using Alternate No. 1 between Stations 390 and 1180 would definitely be a benefit to them. The Bureau of Indian Affairs has recently begun design on a portion of their planned roadway. Construction is scheduled in the next fiscal year for the first 12 miles of the Indian Service Road from Pryor east. They plan to follow the proposed alignment for Alternate No. 1 between Stations 350 and 600. A field review of this alignment with the Bureau of Indian Affairs, Federal Highway Administration, and Morrison-Maierle personnel was conducted in October of 1970 and tentative approval was given to this alignment and design was begun.

It was also learned that the Crow Tribe and the National Park Service have a signed agreement concerning the location of any road crossing the National Park Boundaries. Alternate No. 1 has the preliminary approval of both of these agencies. The agreement gives the Crow Tribe and the National Park Service joint control of any route location which may affect the National Recreation Area proposed road network.

CONCLUSIONS

It is our conclusion that Alternate No. 1, including the upgrading of Blue Creek Road and a portion of Pryor Creek Road, is the most appropriate alignment for further development, design and ultimate construction. It will best meet the public needs and interests for the least expenditure of public funds.

When the two alternates are compared, disregarding the joint usage section of roadway, Alternate No. 2 has both a lower initial construction cost and a lower total annual cost. It is also 2.4 miles shorter, resulting in lower road user operating costs.

However, consideration of the concept of the joint usage section appears to be valid. The Bureau of Indian Affairs has taken positive steps in the accomplishment of their goal of constructing a high standard highway between St. Xavier and Pryor. Their planned route is shown on Figure 2. Three miles of this route have been completed from St. Xavier west including a five-span bridge over the Big Horn River. Another 12 mile section extending easterly from Pryor is now under contract for surveys, mapping and design. About 4½ miles of this alignment coincides with that of our proposed Alternate No. 1.

When the costs of Alternate No. 1 are reduced to reflect the savings of not having to construct parallel routes, this alternate then becomes the most economical. Initial construction cost for the new and upgraded portions of Alternate No. 1 are $1,398,300 less than for Alternate No. 2. The total annual cost is lower by $36,800. The annual operating cost for Alternate No. 2, however, is lower than for Alternate No. 1.

This figure is based on traffic bound only from Billings to Bighorn Lake. An advantage of Alternate No. 1 which is not reflected in these road user costs, is that the traffic bound from Pryor to Bighorn Lake and from Pryor to St. Xavier would benefit by being able to use a portion of this alignment.

Another advantage of Alternate 1 alignment, which includes the upgrading of 7.8 miles of Pryor Creek Road, is that this County road will undoubtedly require improvement at some time in the future regardless of which Alternate is constructed. This would be an added expenditure of $404,600 with Alternate 2, whereas with Alternate 1 the improved section would be used as a part of the main route from Billings to Big Horn Lake.

The construction of either alternate would be a great benefit to recreation oriented traffic, the majority of which would originate in the City of Billings. The increasing public demand for leisure time facilities and the proximity of the Bighorn Lake National Recreation Area to a major population center point out the need for a shorter route. Alternate No. 1 provides a route which is 35 miles shorter than the existing route. Annual savings to the road user would be $1,038,700 when compared to the present route of I-90 and Montana 313.

With only a single exception, Alternate 1 received the endorsement of every offical group known to have an interest in the Study. The Crow Indian Tribe and the National Park Service, two vitally concerned agencies, are among the proponents of Alternate 1.

Either Alternate would benefit the local economy. They would both provide access to areas that at present have virtually no all-weather roads. However, Alternate No. 1 would serve approximately eight ranches whereas Alternate No. 2 would serve only two. Alternate No. 1 would bene-

fit the local economy by providing a ranch to market road which would be usable the year round. It also would provide a badly needed route to transport children to school. The condition of the present roads in the area requires that some children remain in town near their school during bad weather.

Alternate No. 1 also provides the traveling public with a route of aesthetic beauty and with many natural and historic landmarks nearby including Indian campsites, battlegrounds and buffalo jumps. It closely follows the historic Bozeman Trail and offers more distant views and more colorful contrasts of geologic formations.

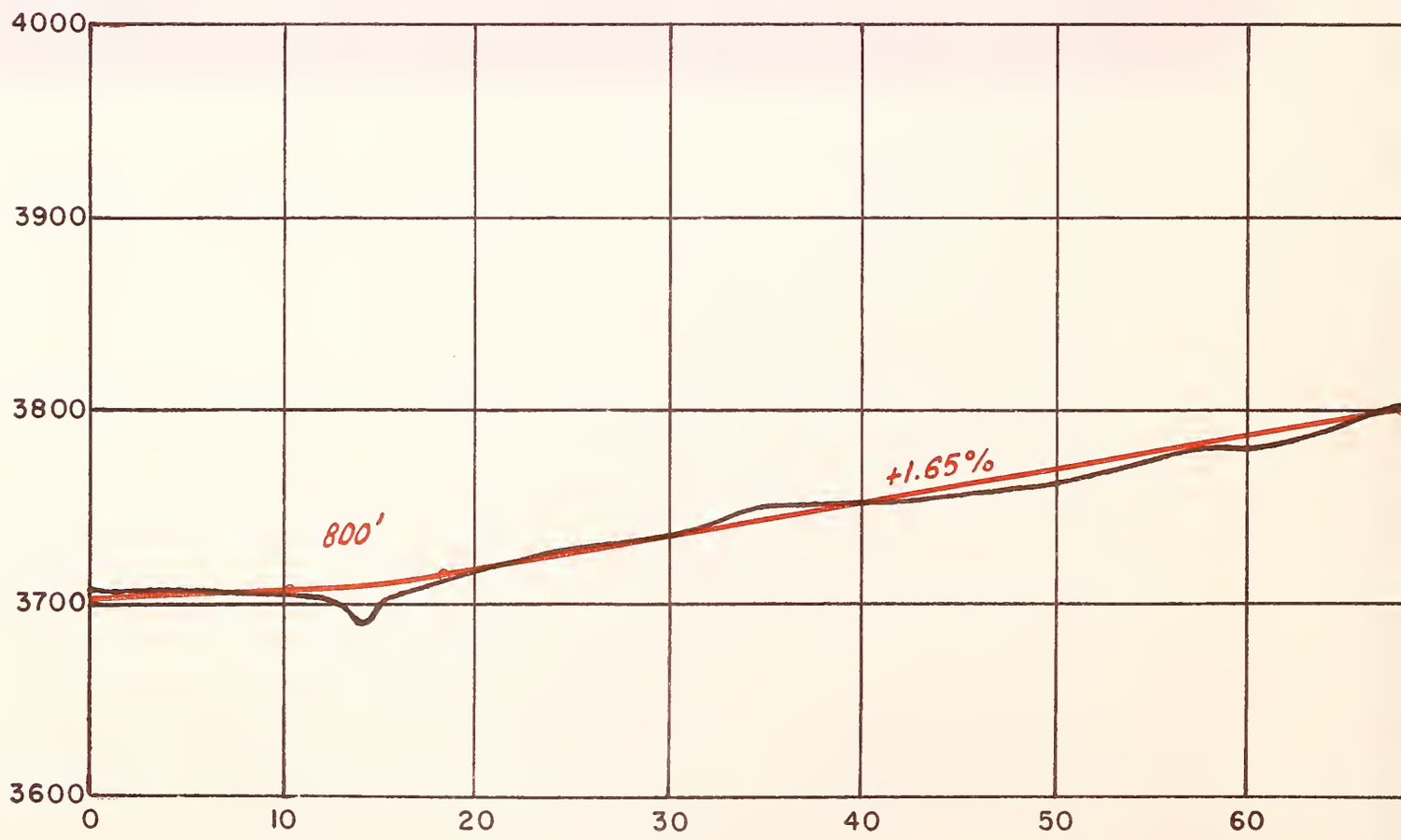
In summary, the construction of Alternate No. 1 as a shorter, more direct highway between Billings and Bighorn Lake, will serve the best interests of the public from the standpoint of usefulness, economic considerations, convenience, safety and aesthetics.

Alternate No. 1

PLAN & PROFILE SHEETS

New Construction Only

Prior
STA. 0+00
BEGIN CONSTRUCTION
Creek
50
Creek
Hay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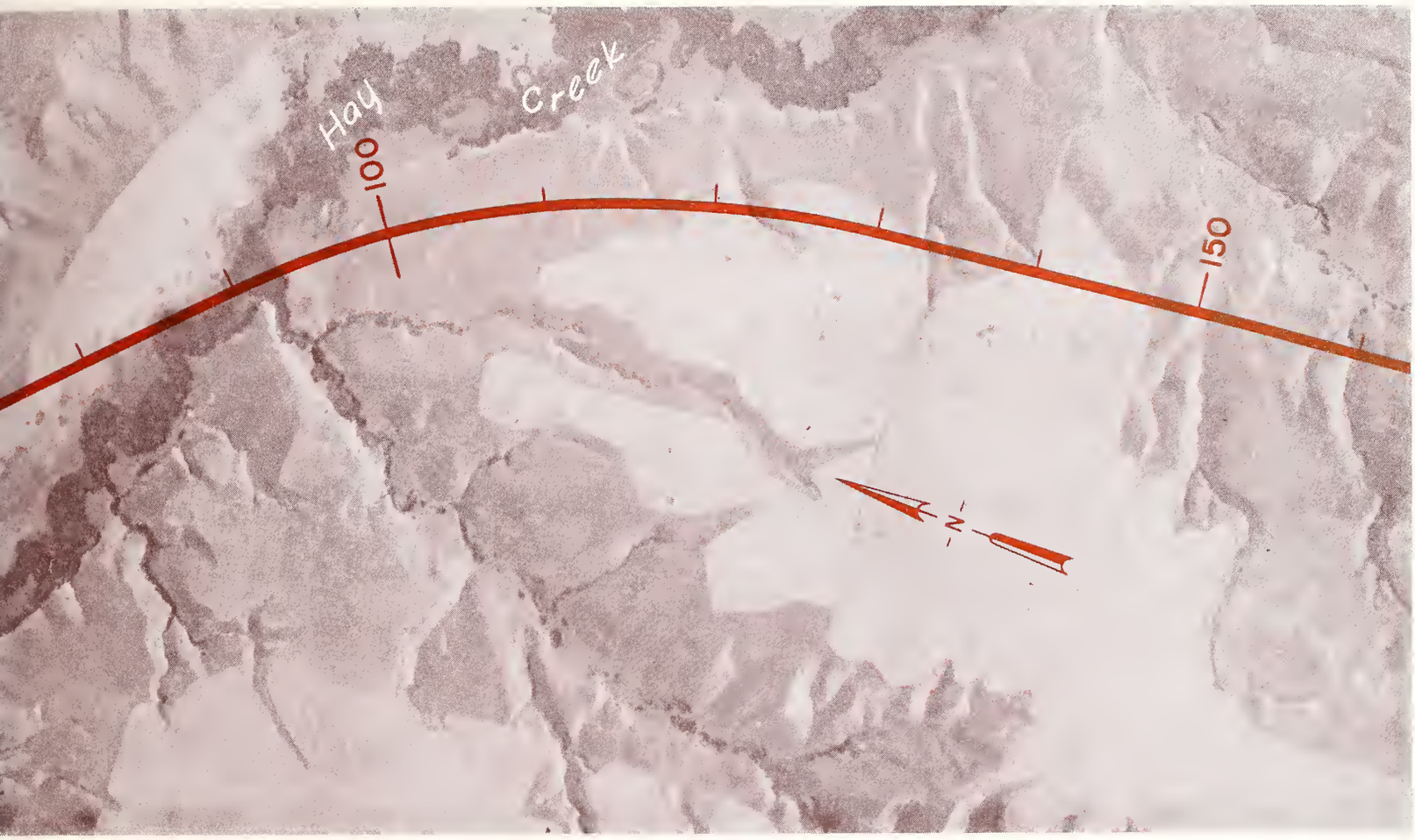
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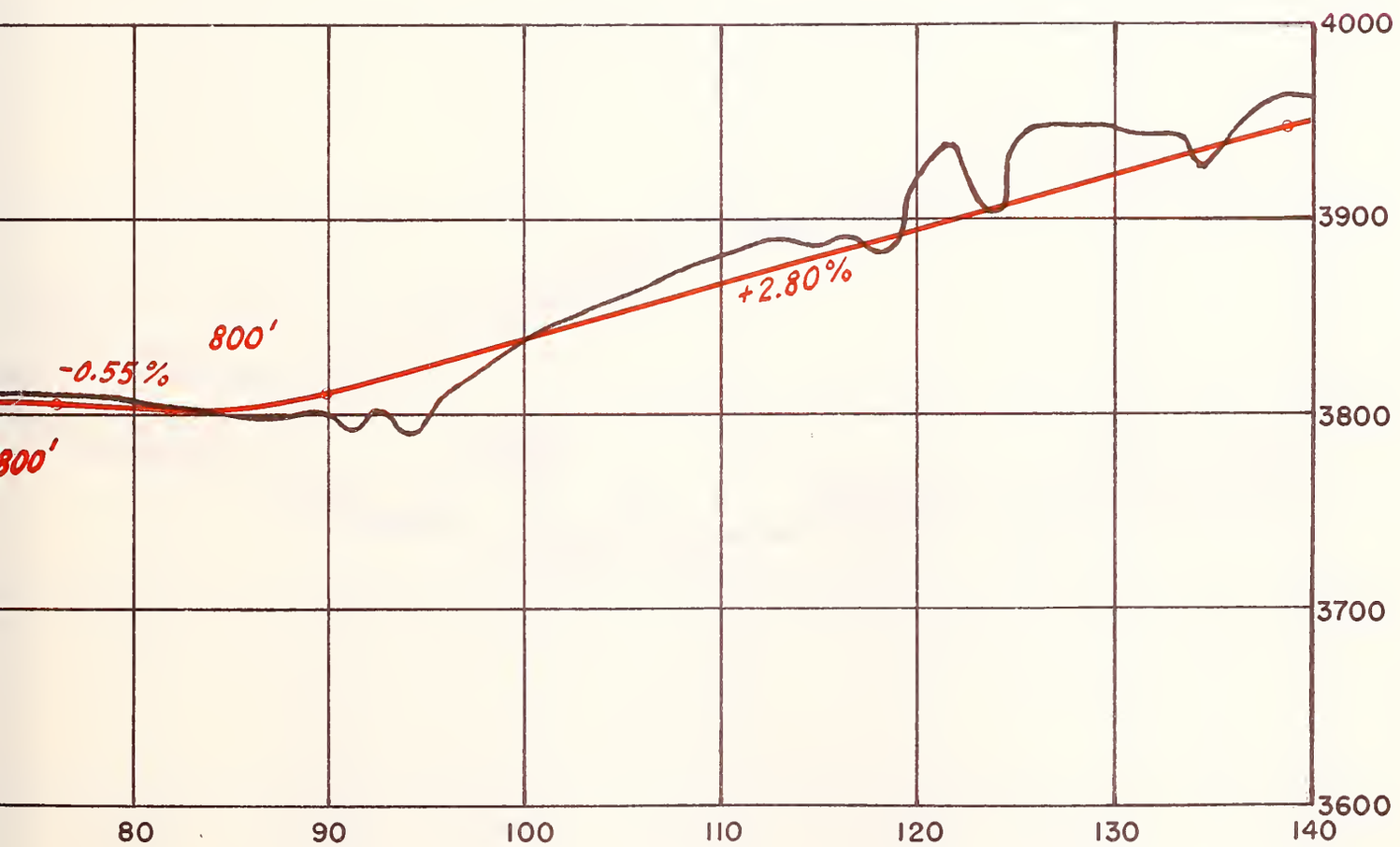
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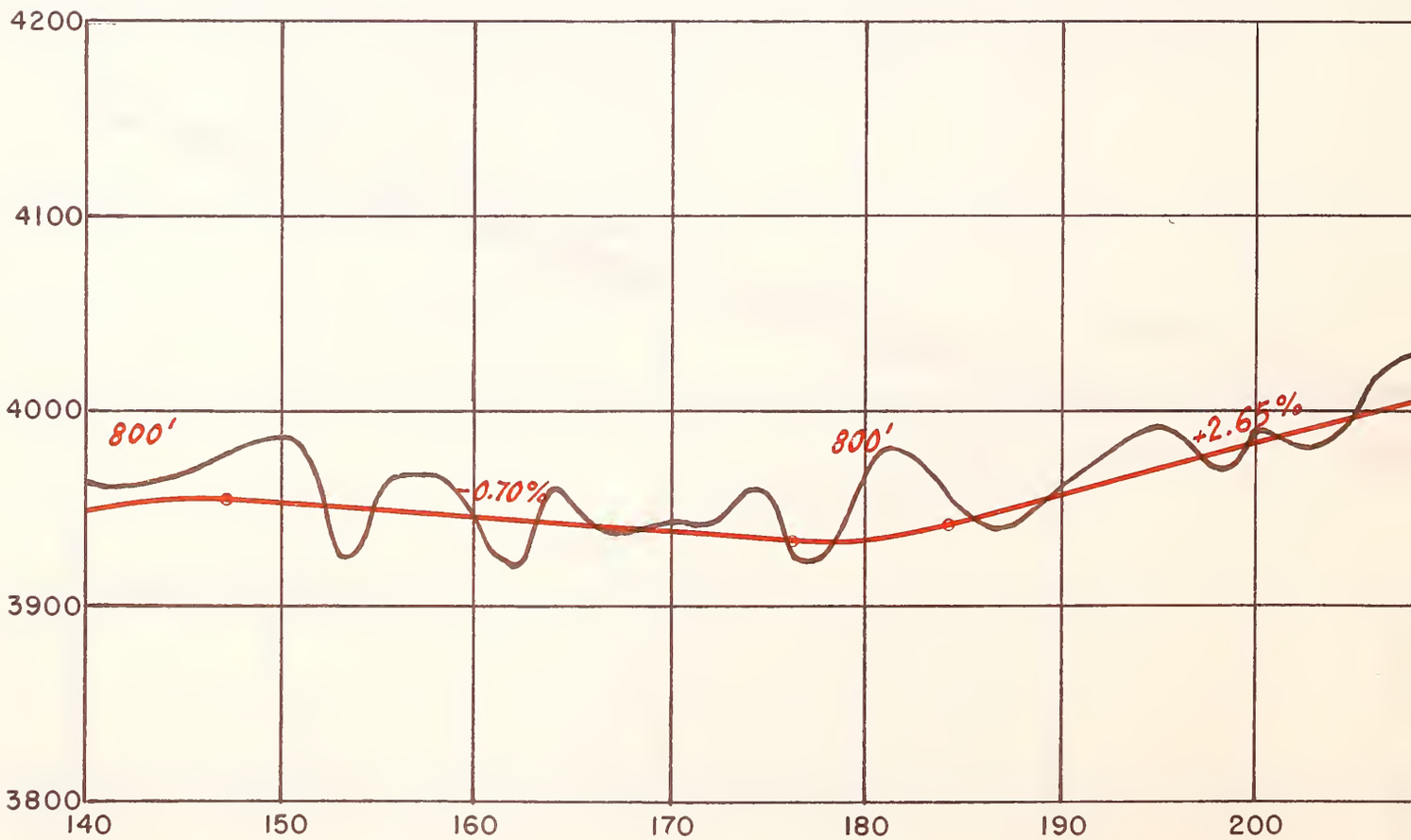
200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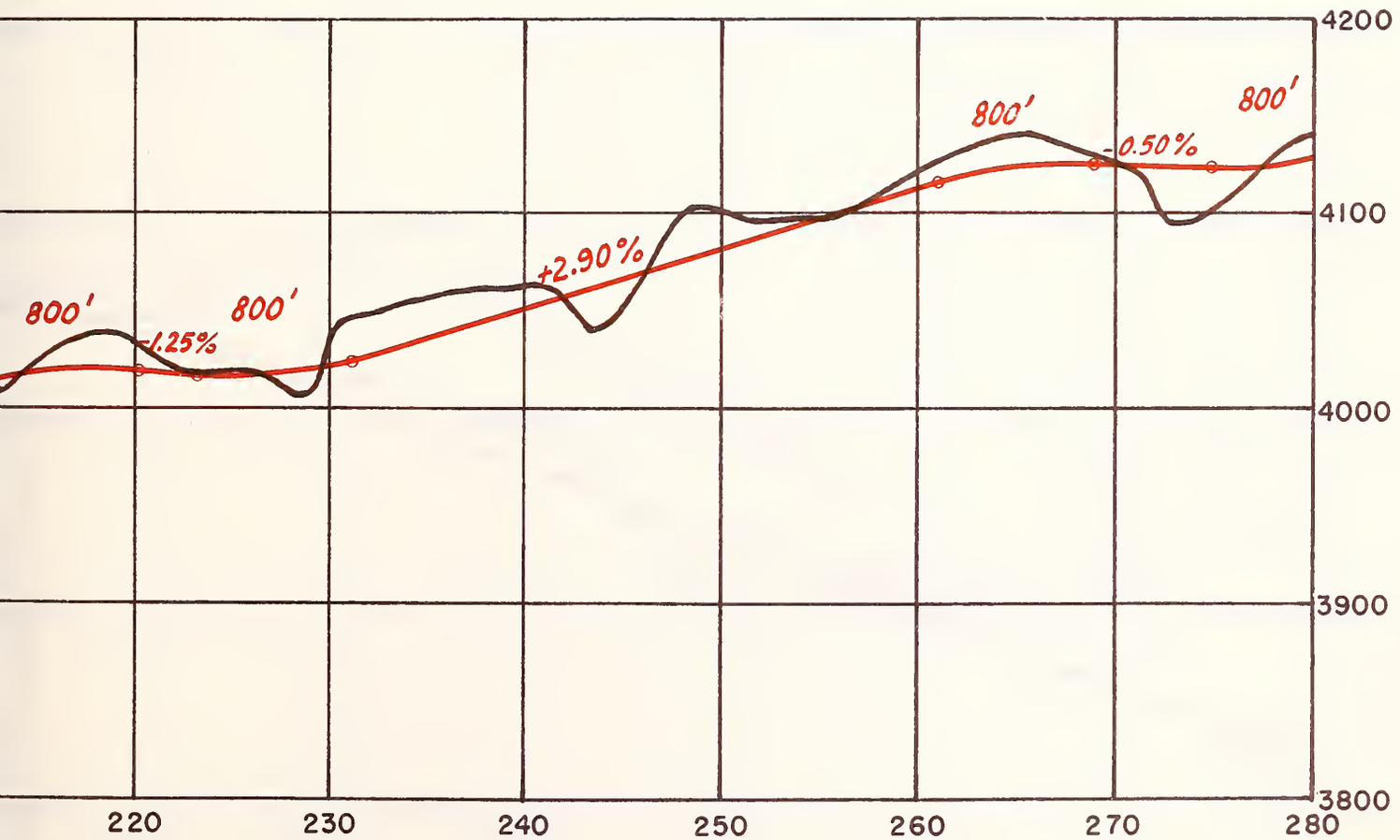
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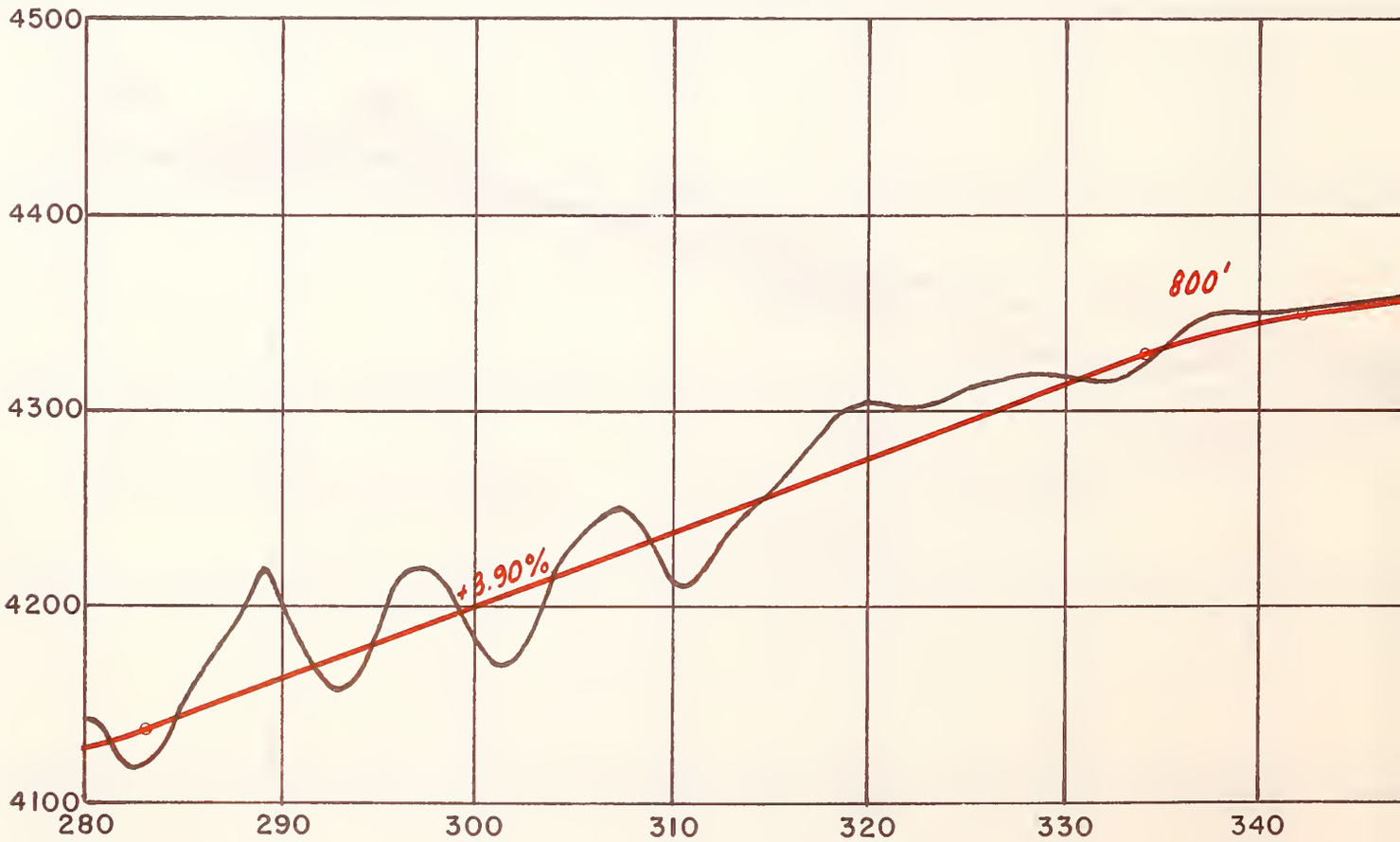
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+3.90%

N
Hay
Creek
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400
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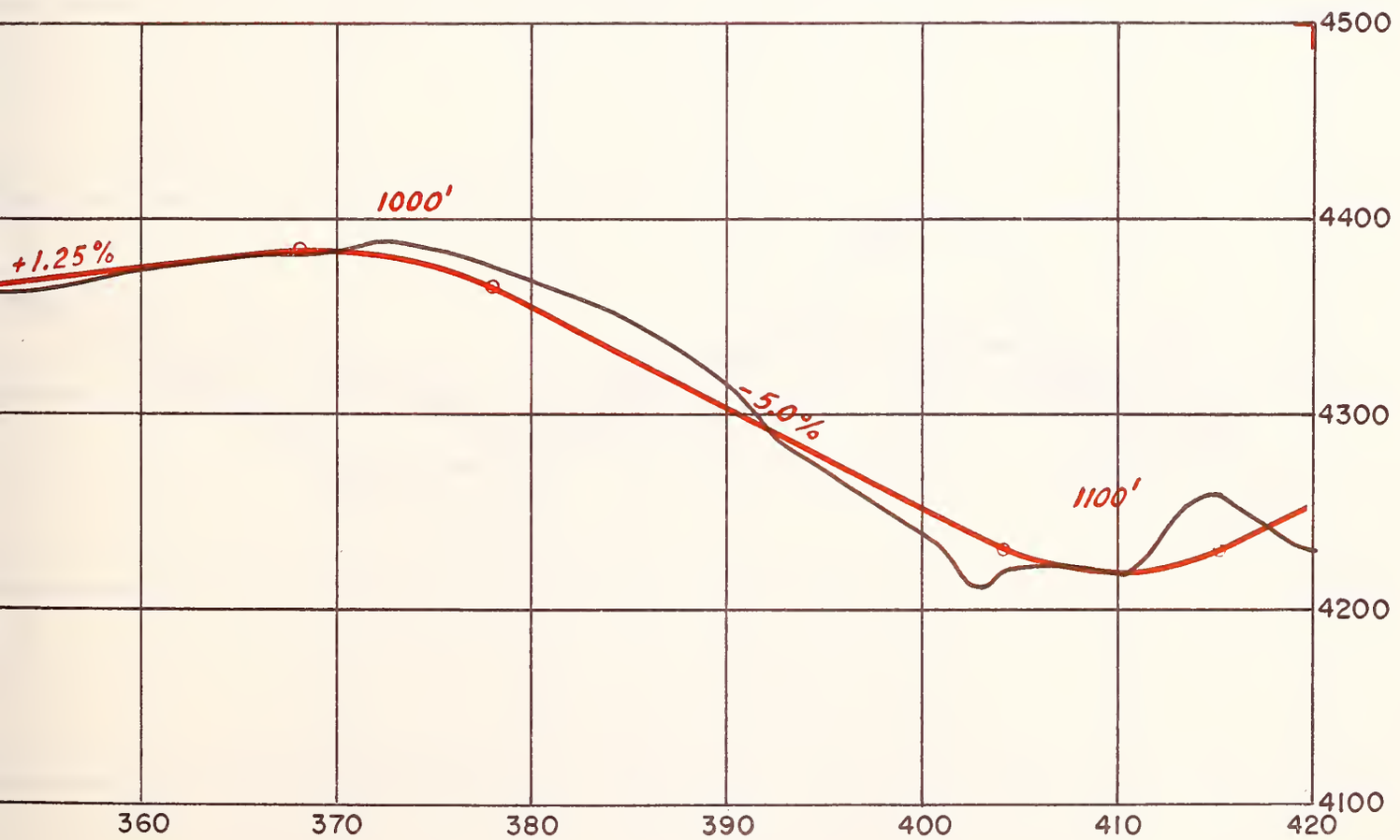
INDIAN SERVICE ROAD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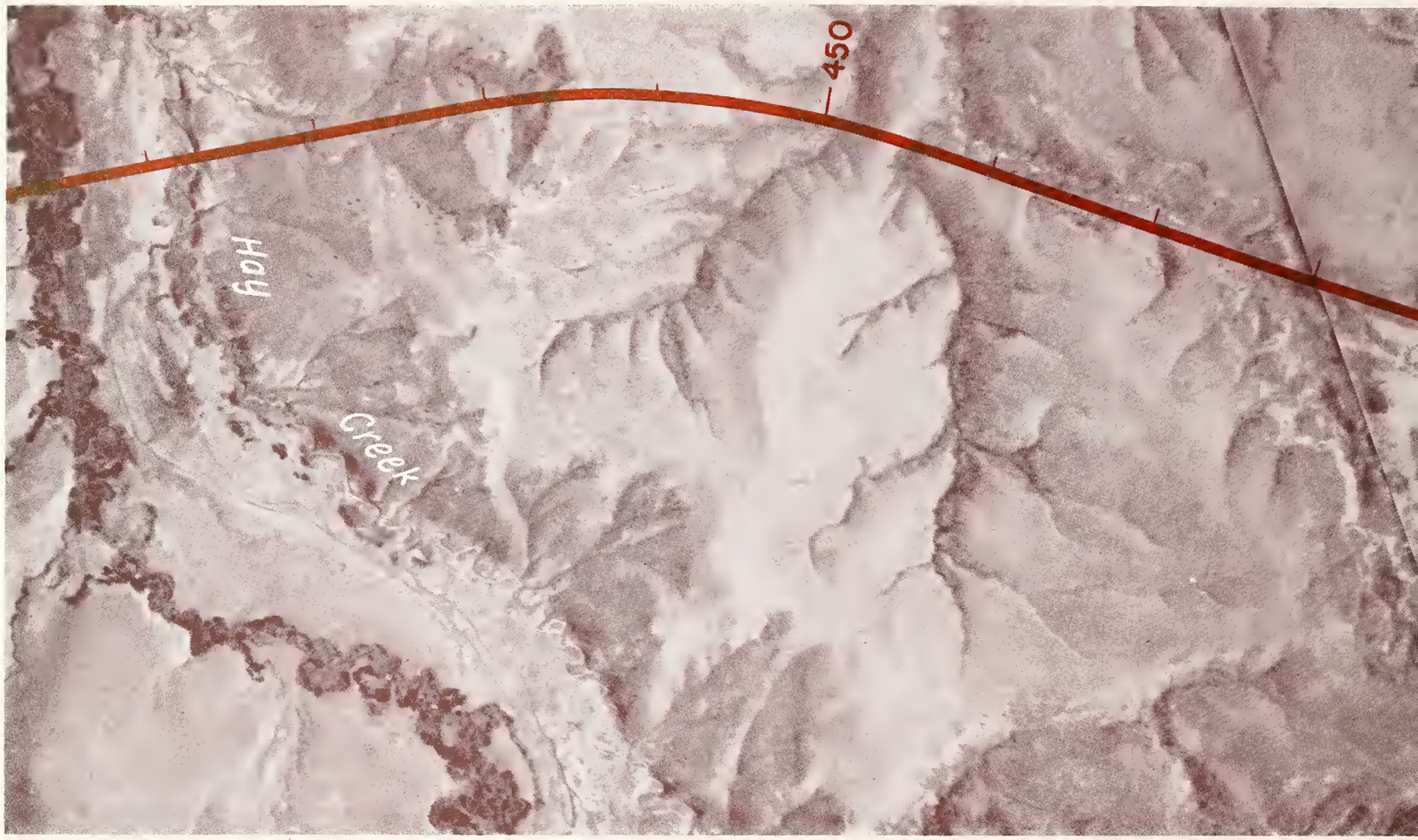
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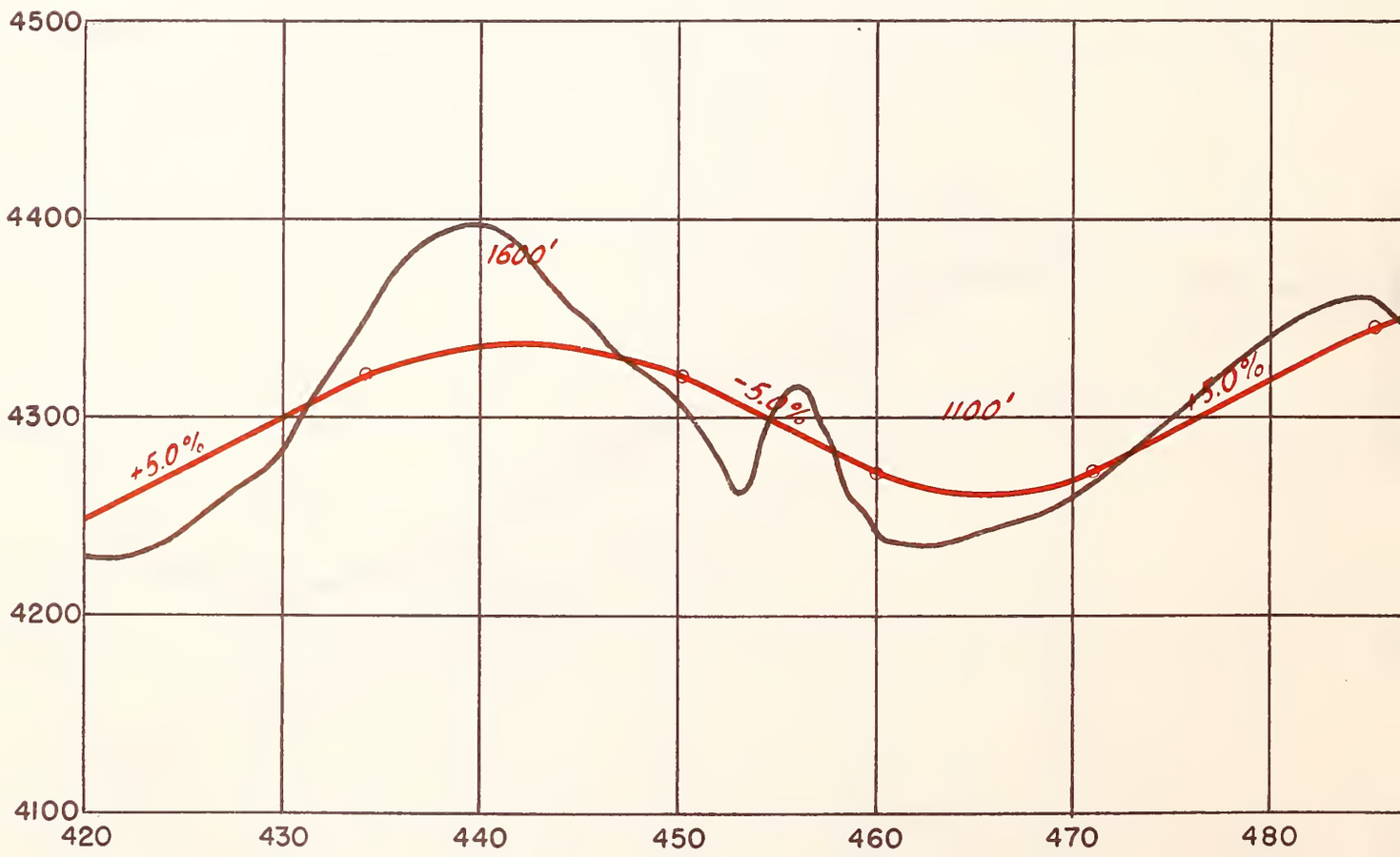
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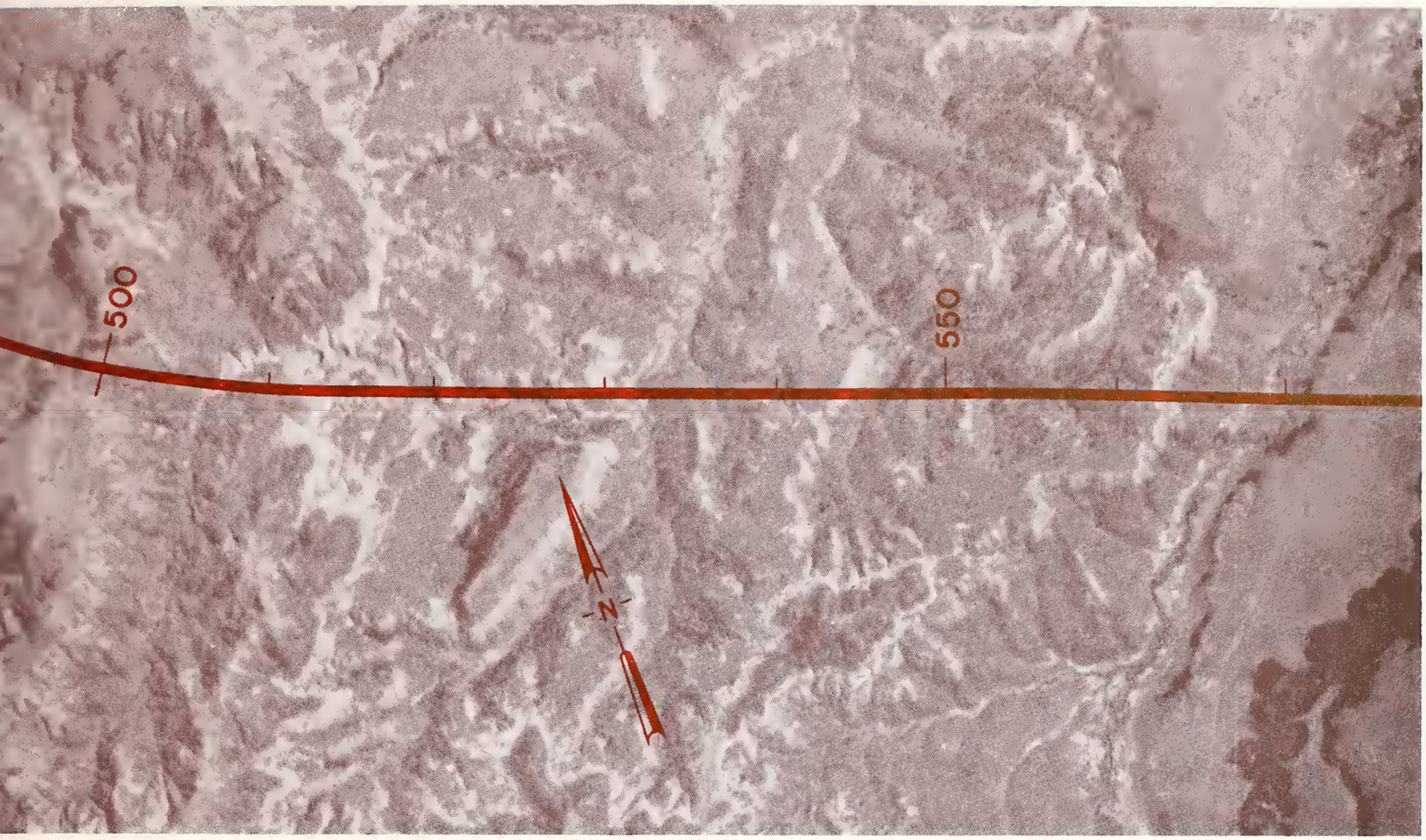
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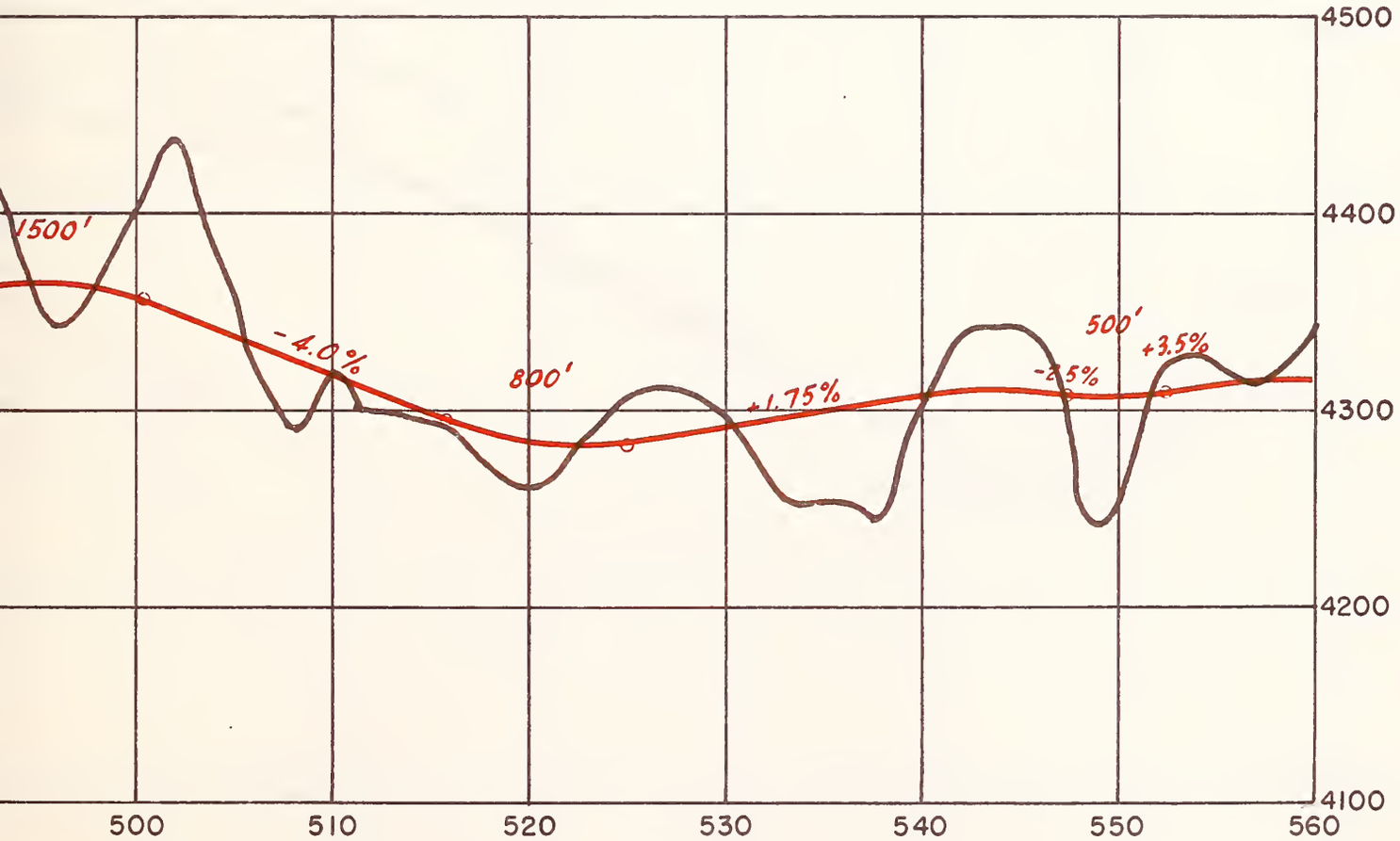
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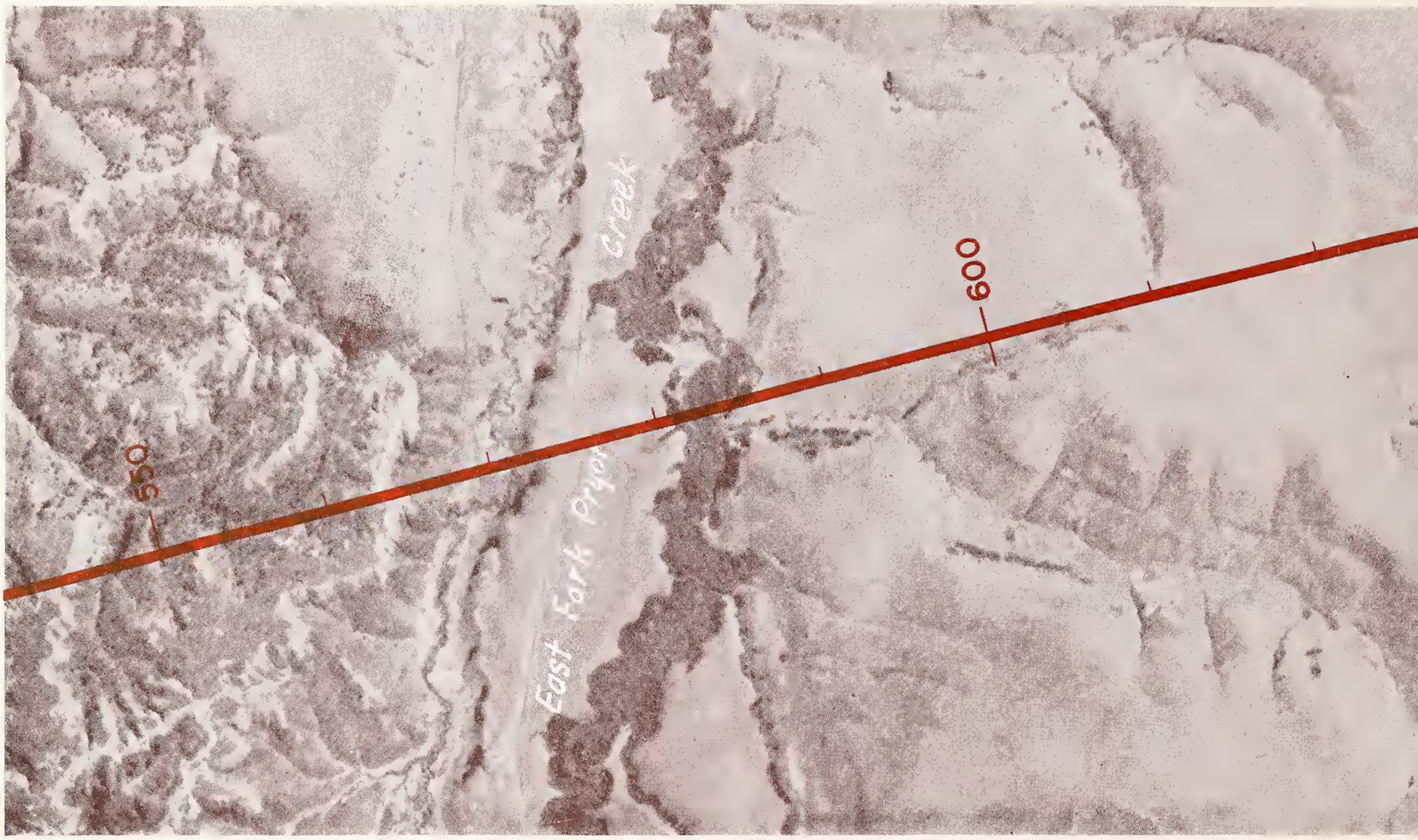
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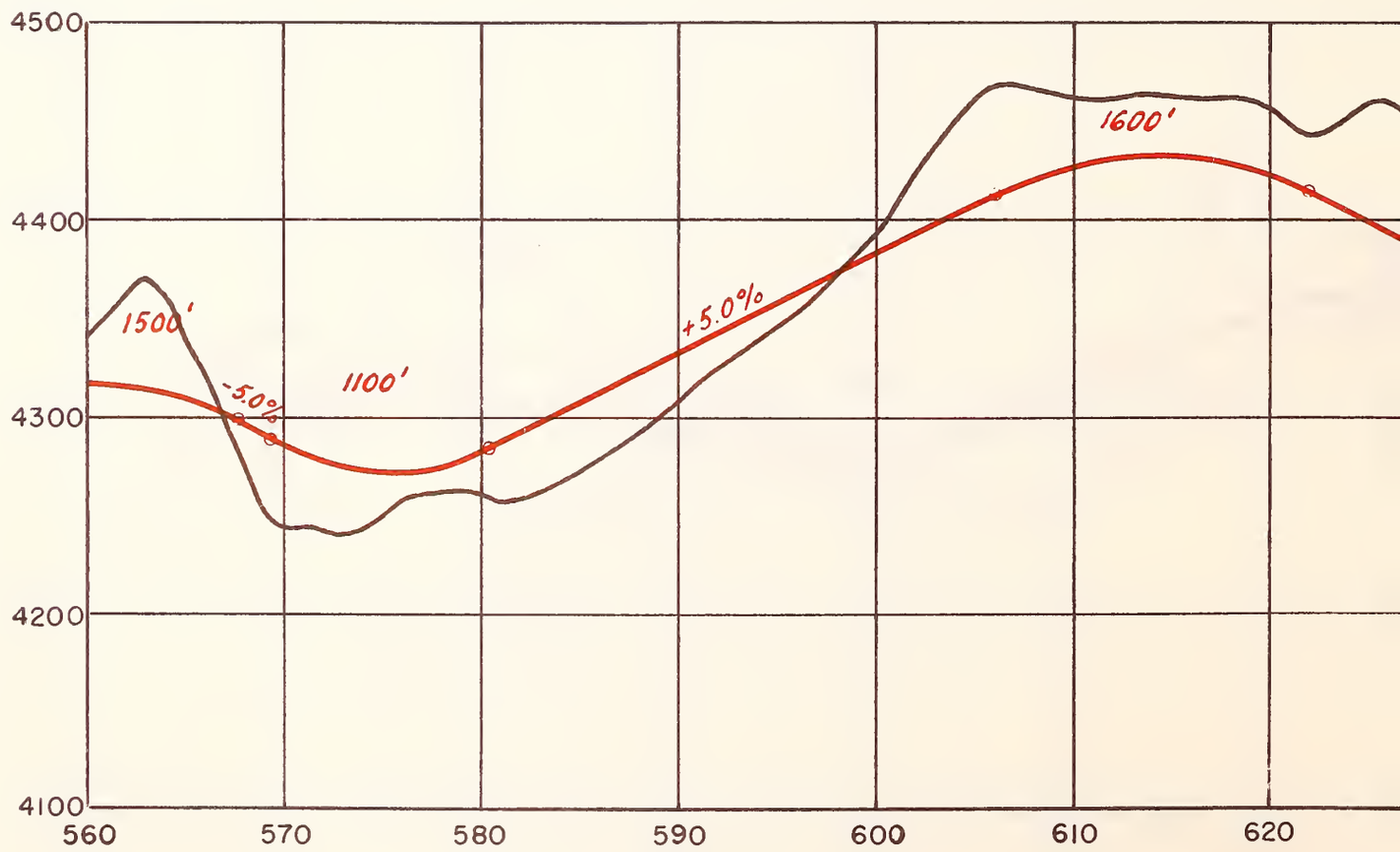
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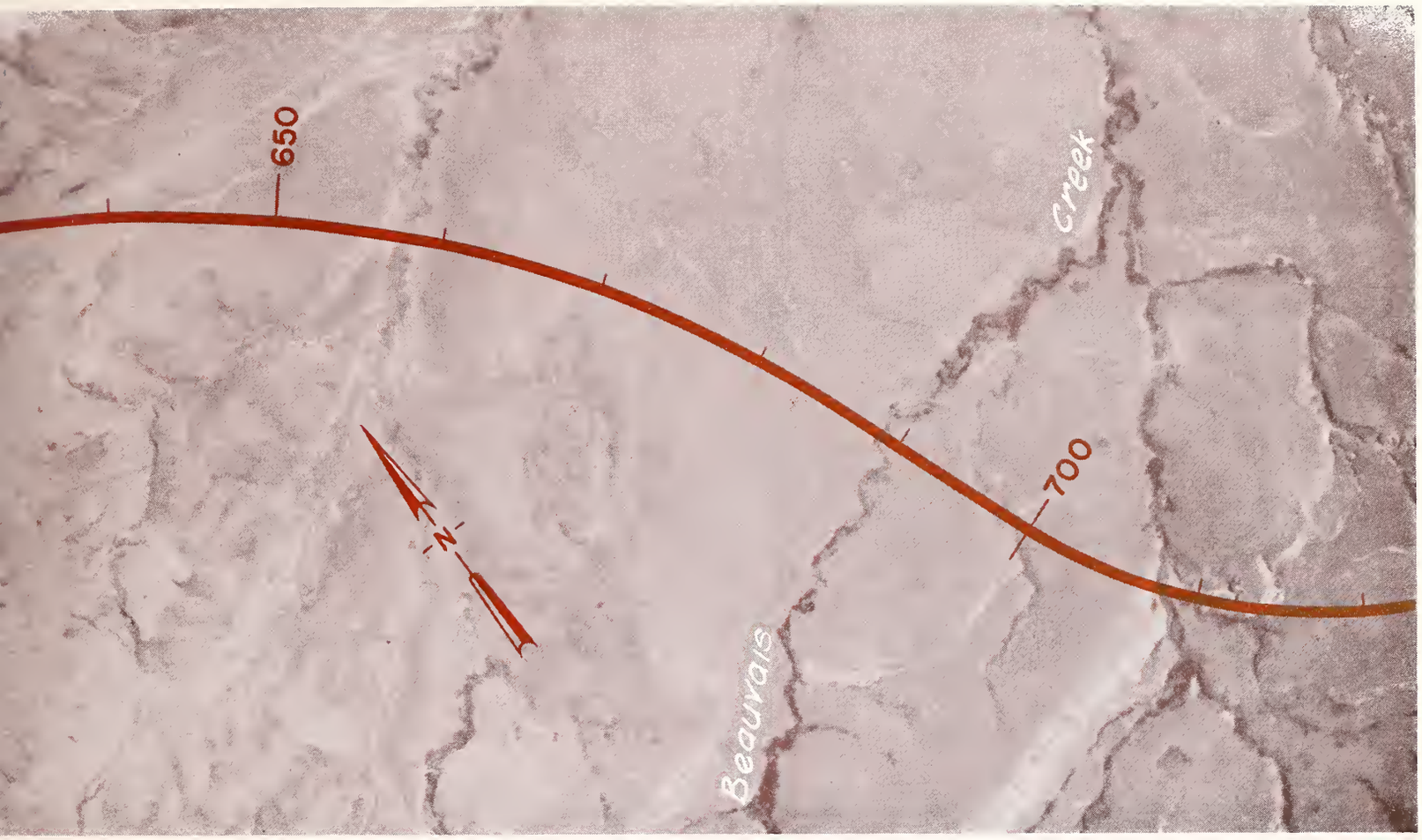
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700
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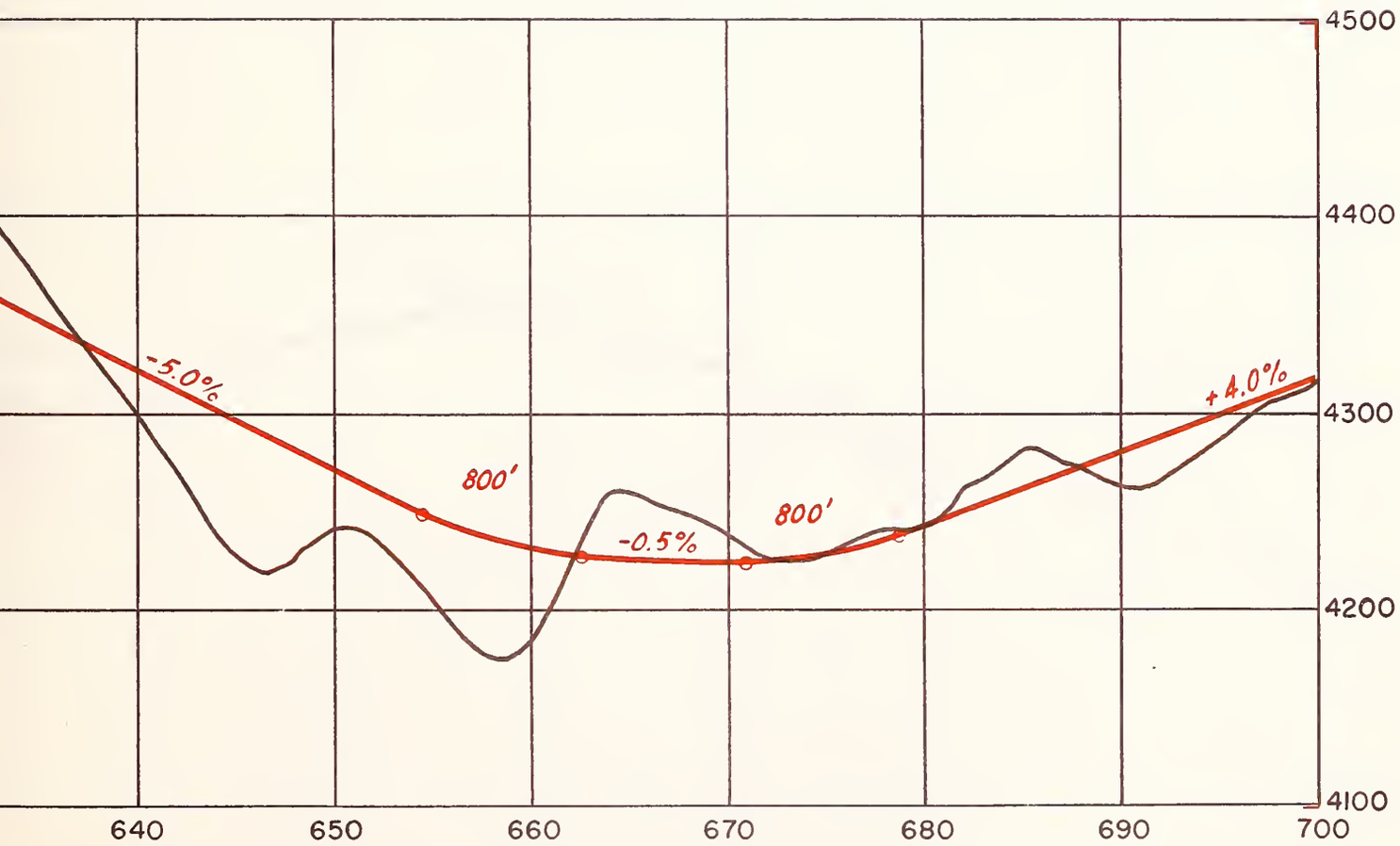
Creek
Beauvais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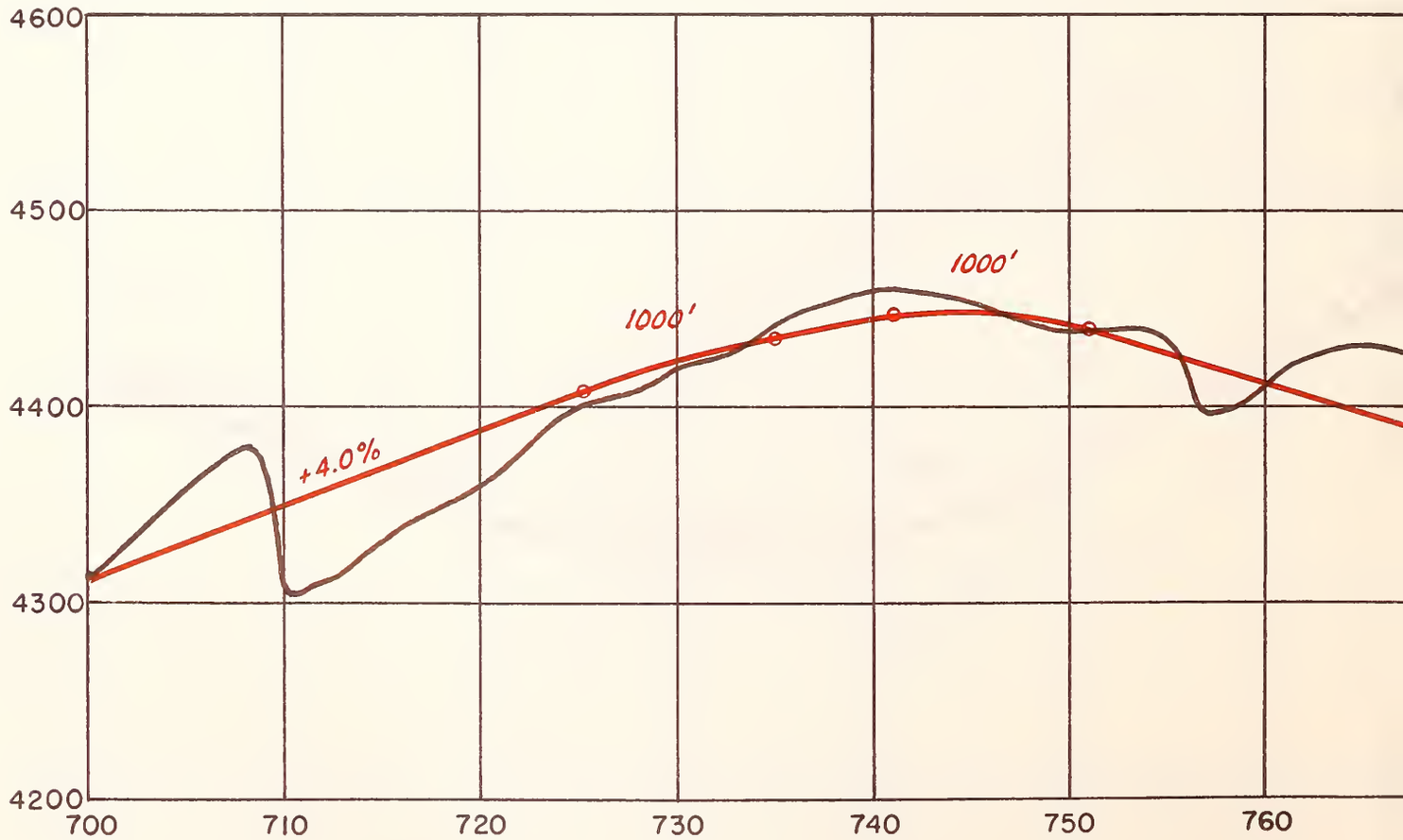
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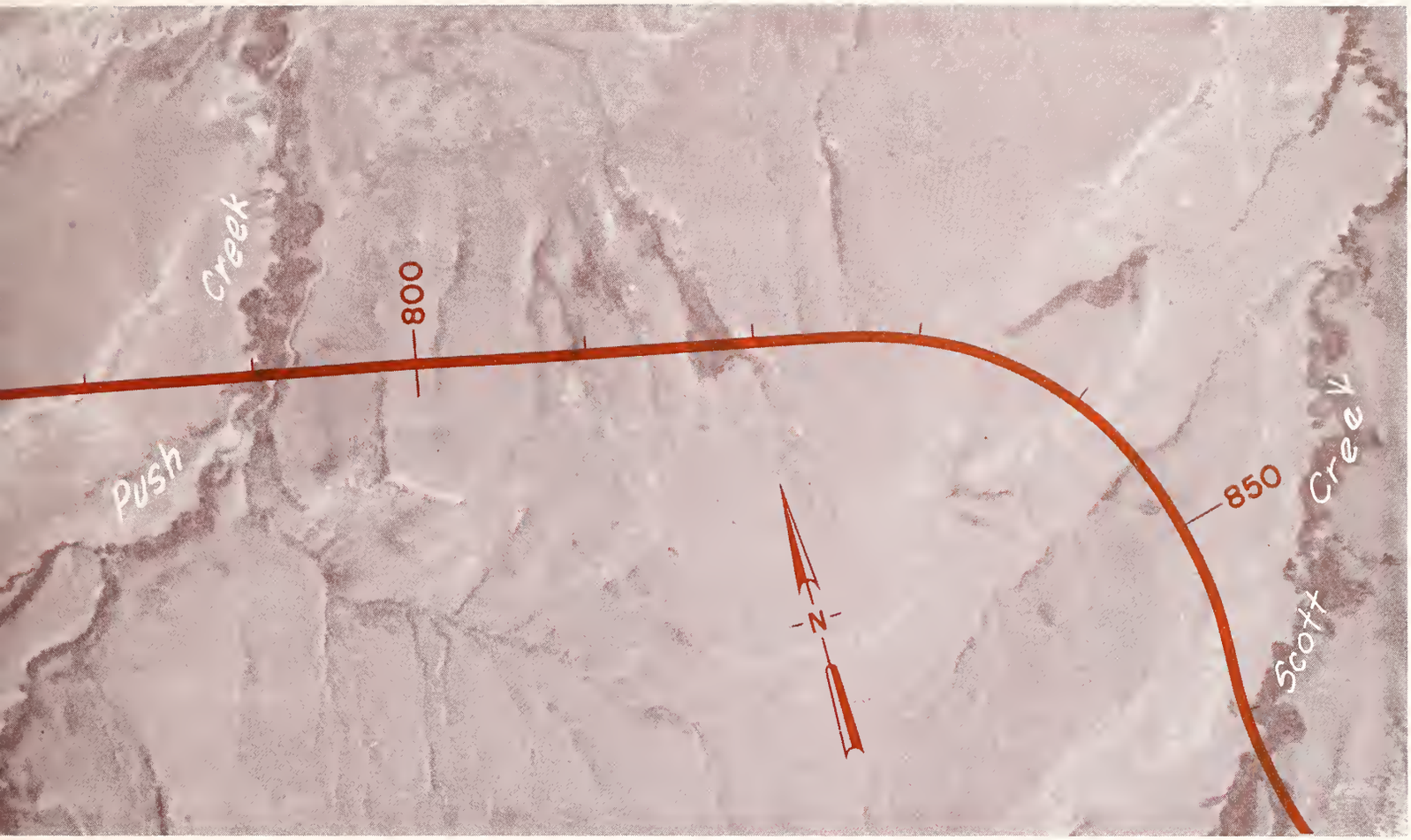
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Scott Creek
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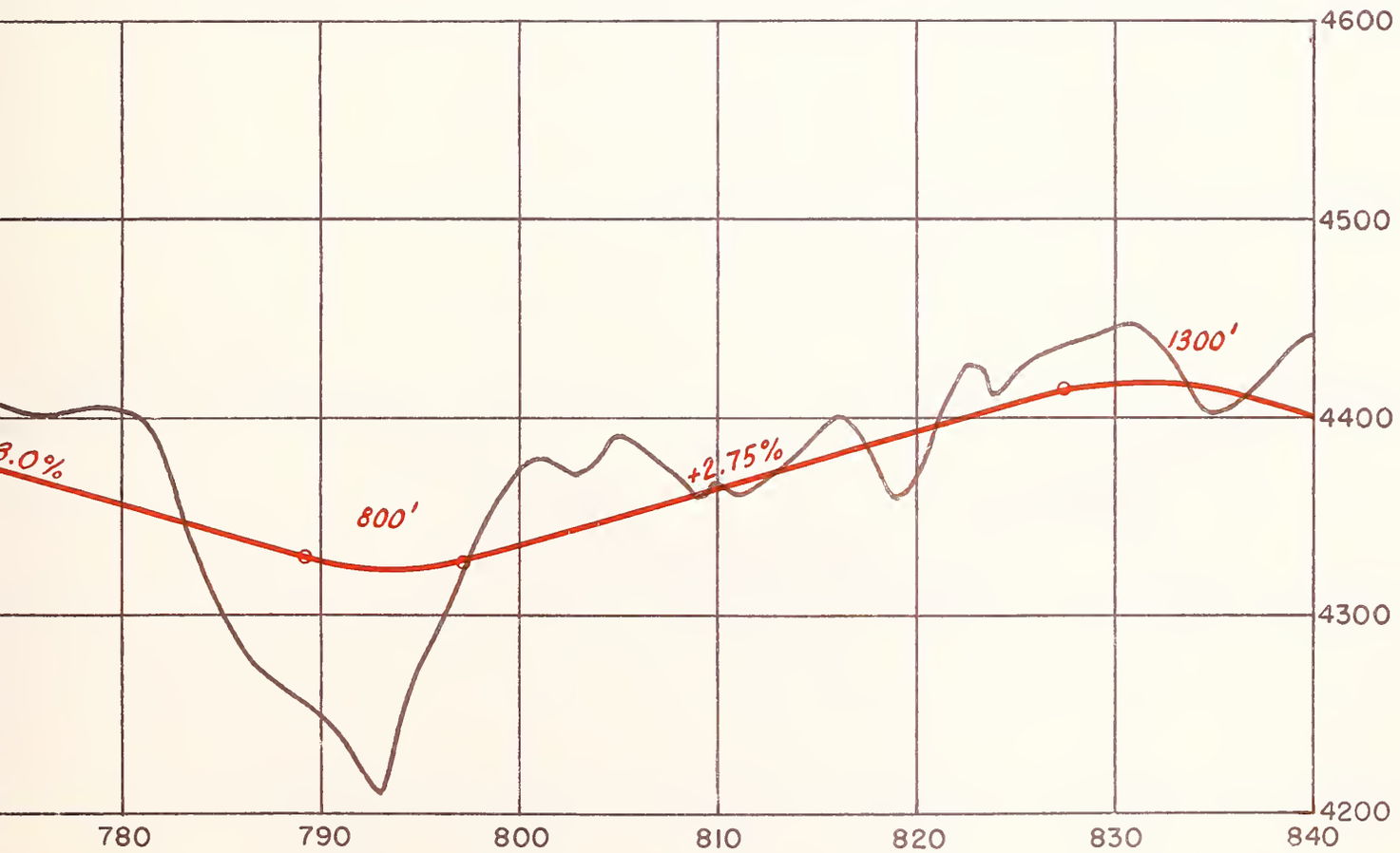
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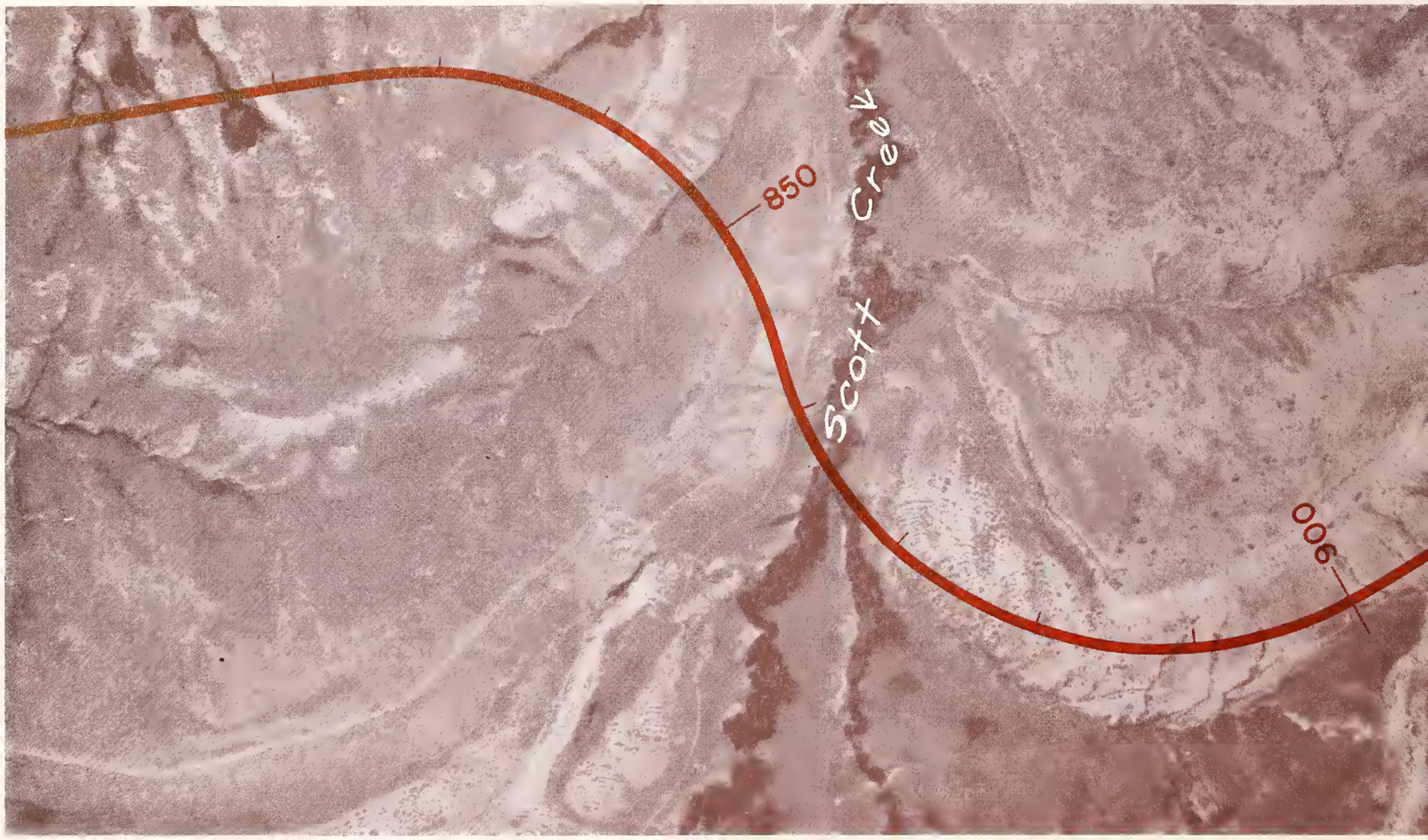
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Scott Creek
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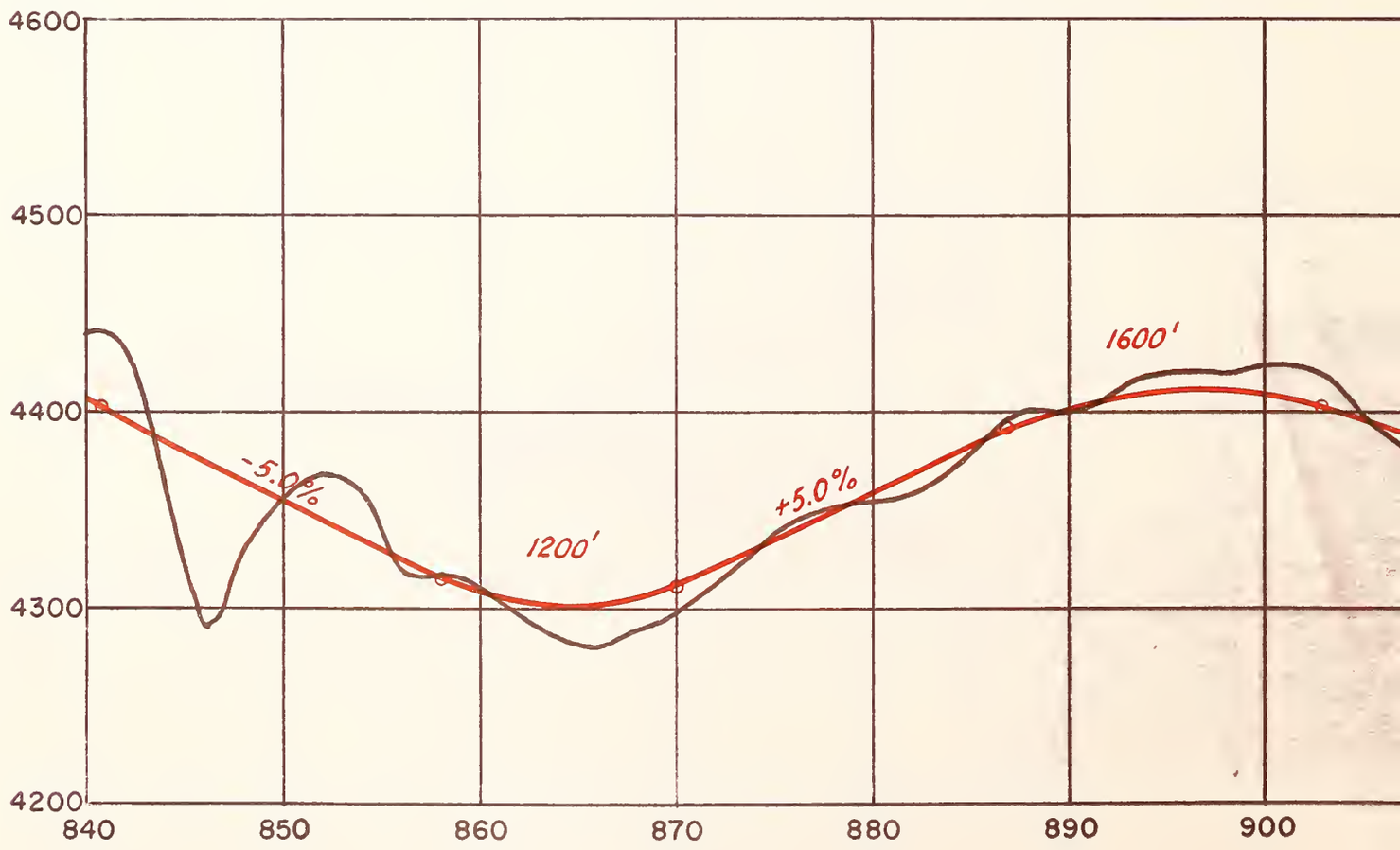
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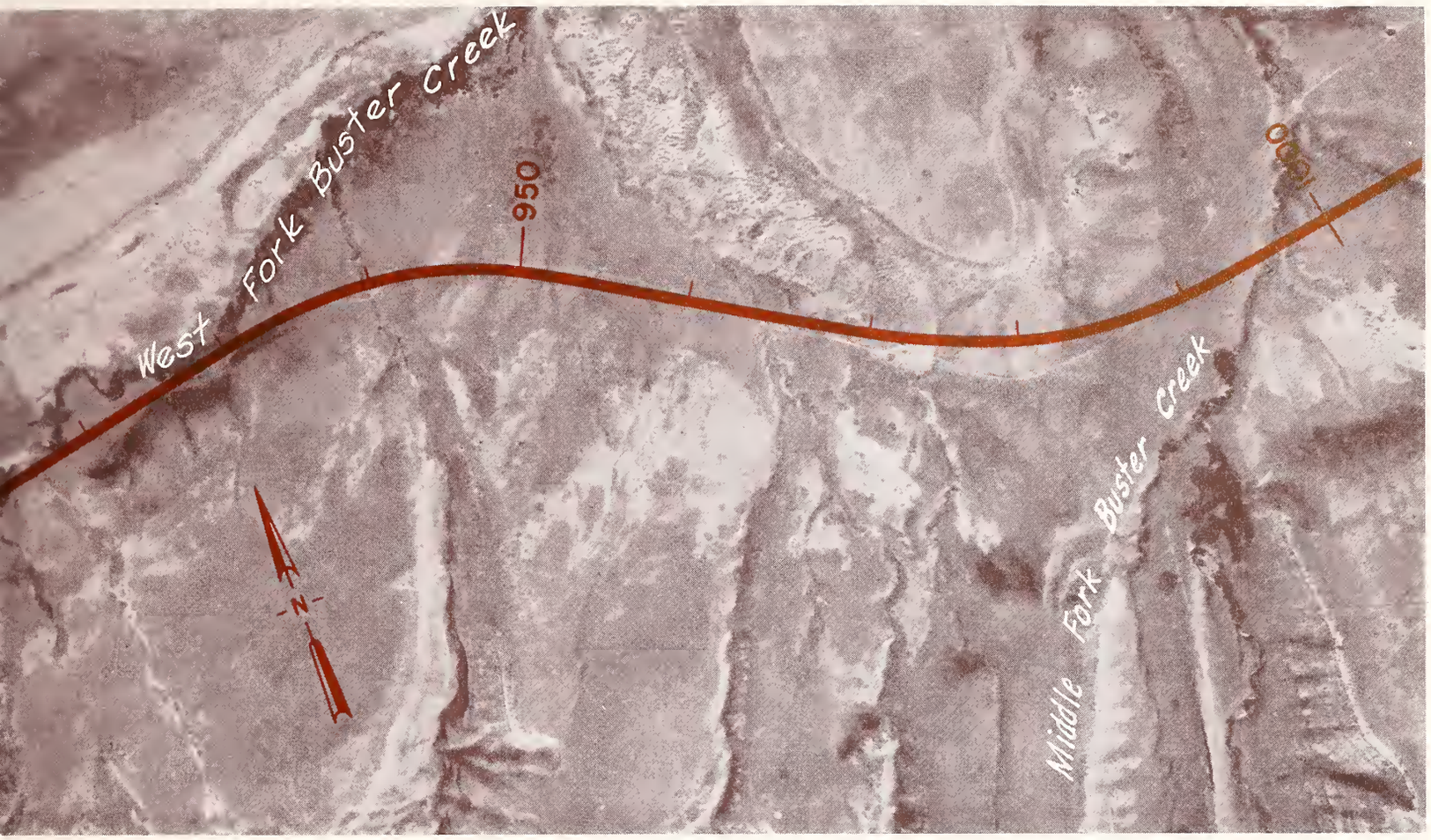
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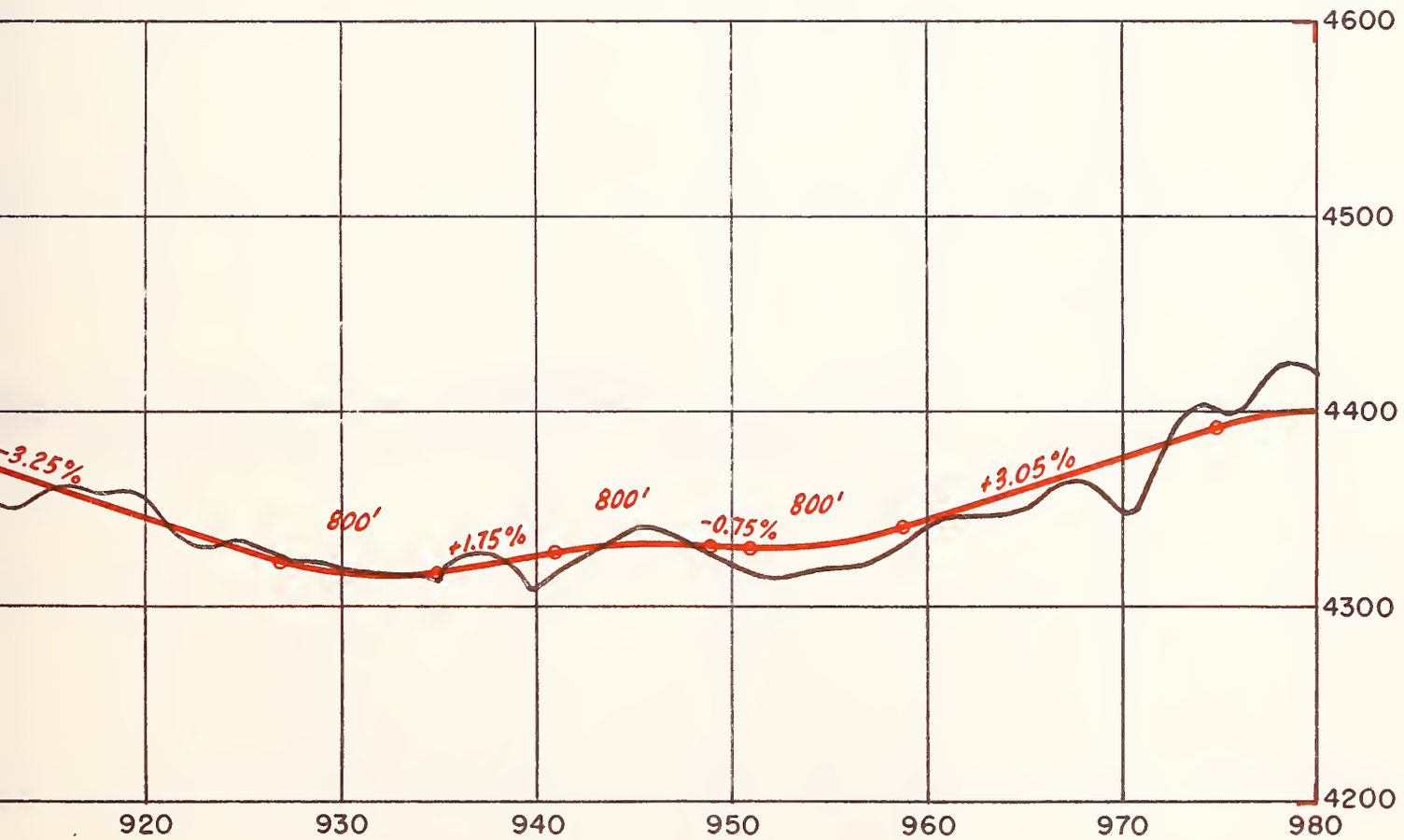
Middle Fork Buster Creek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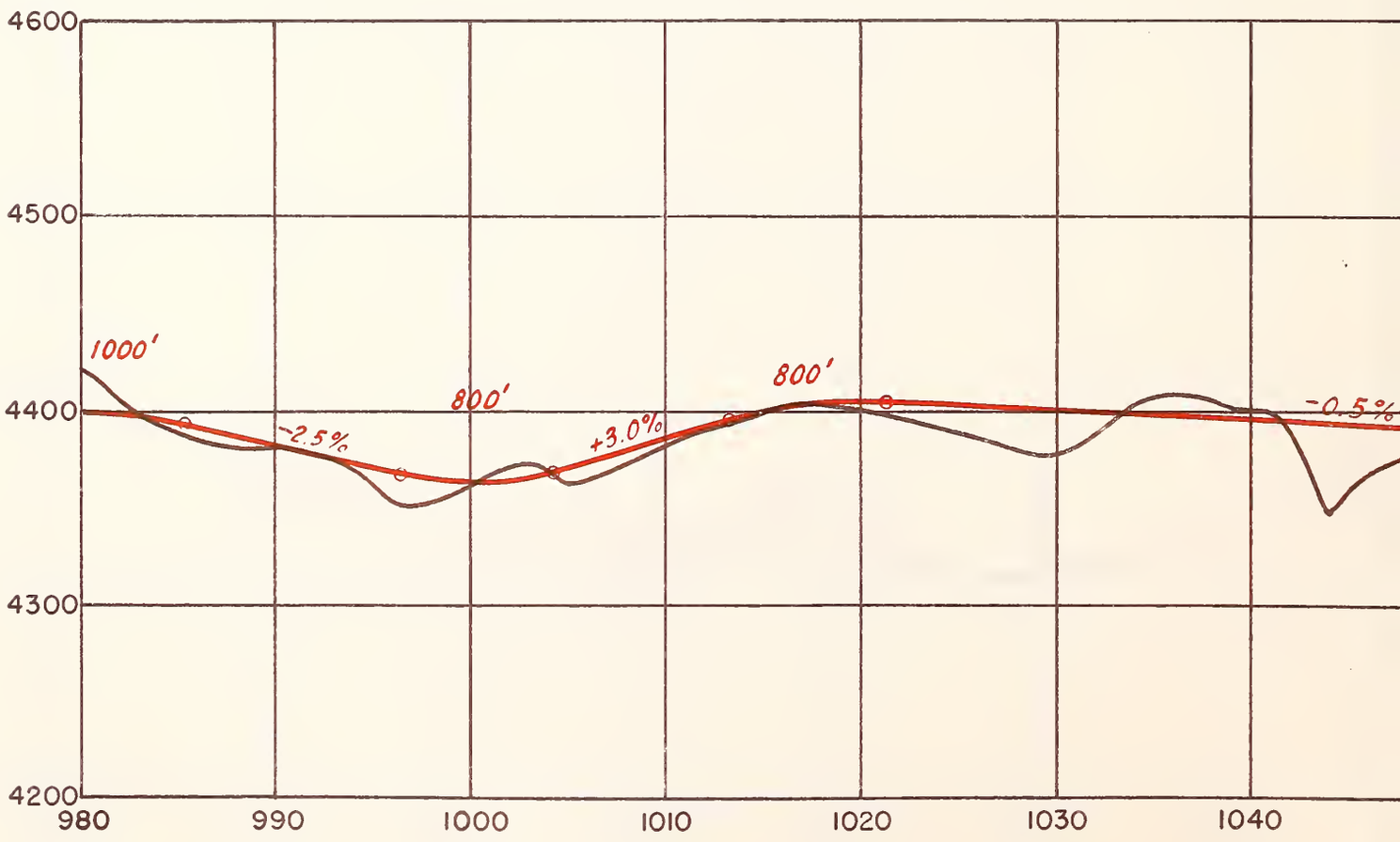
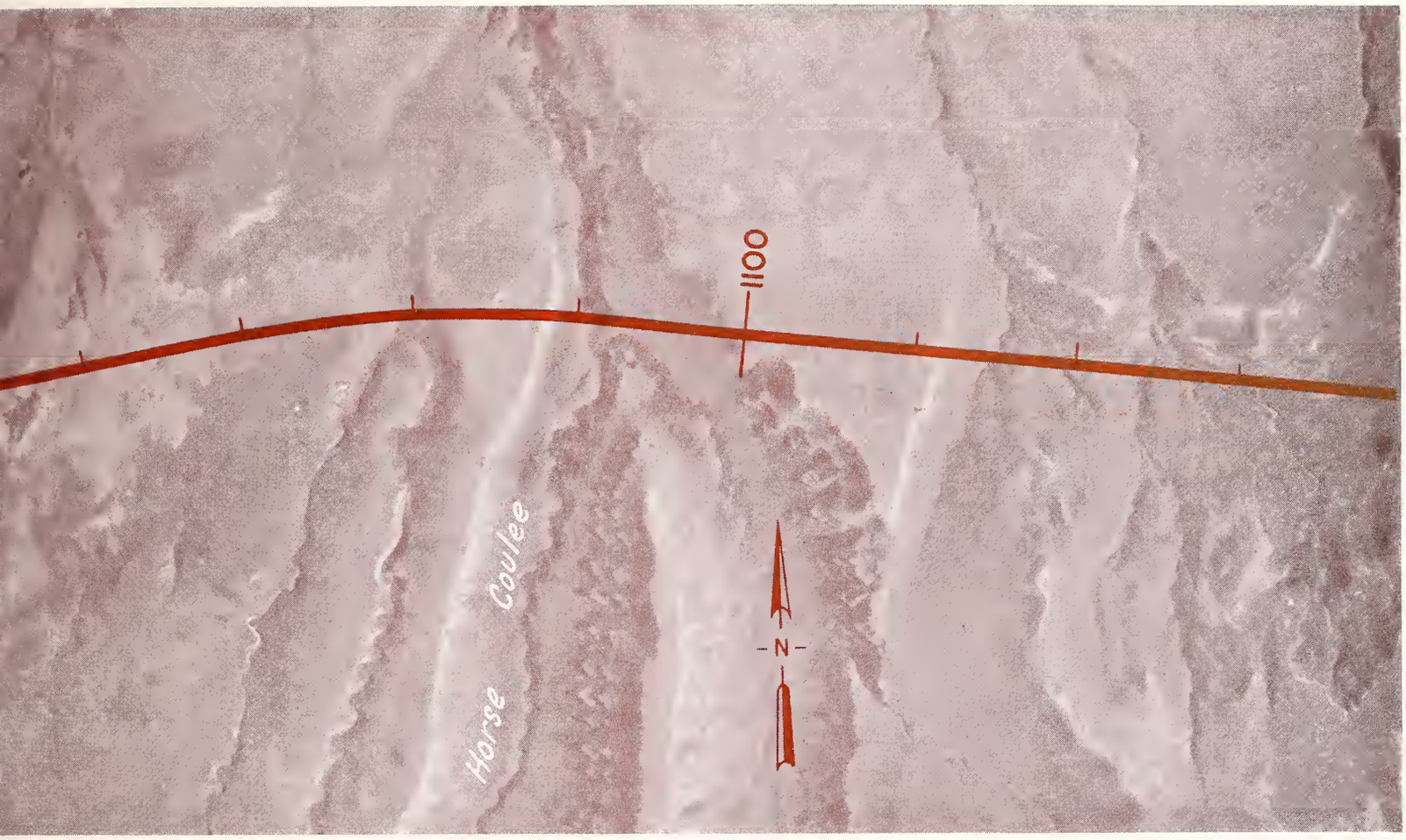
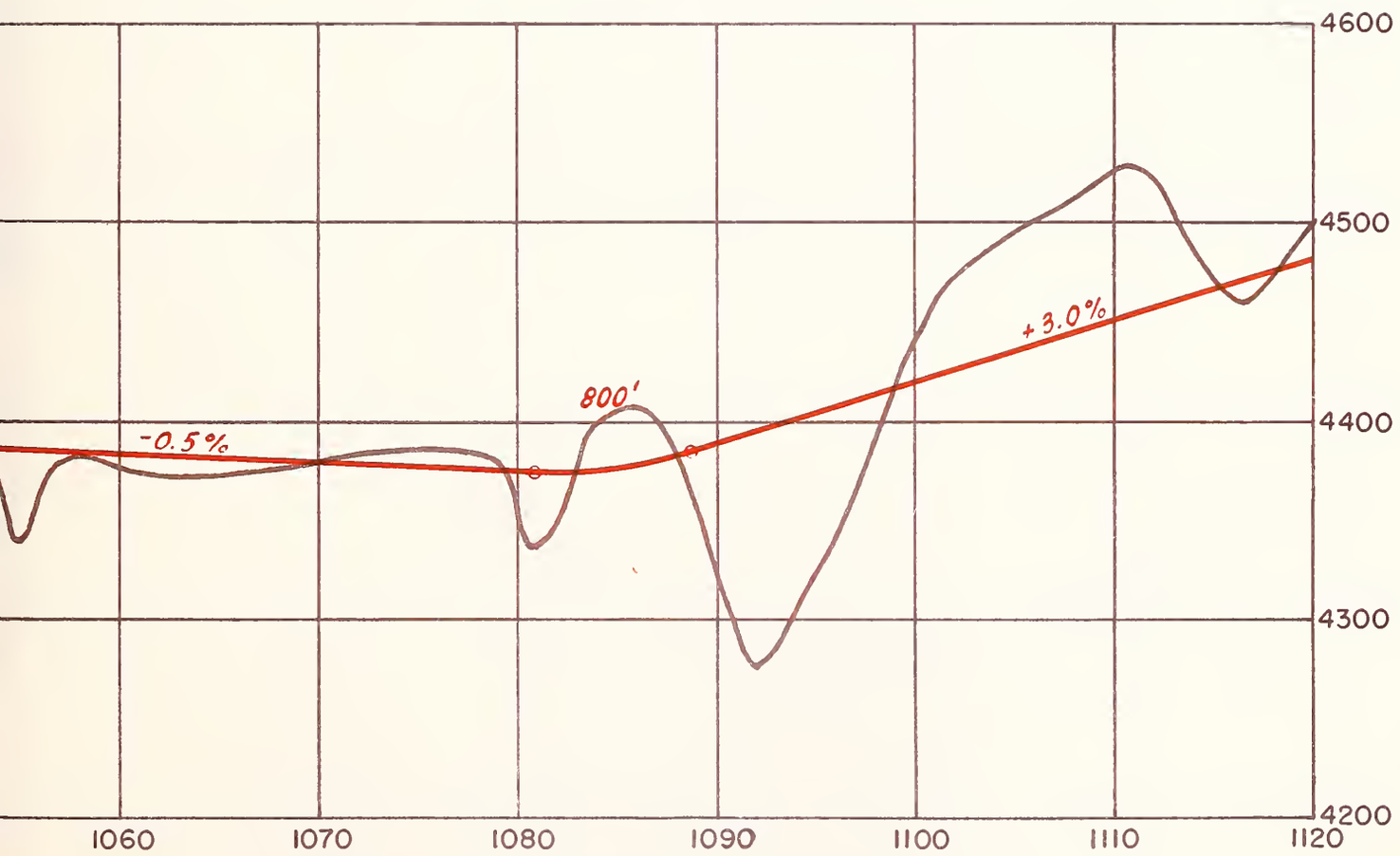
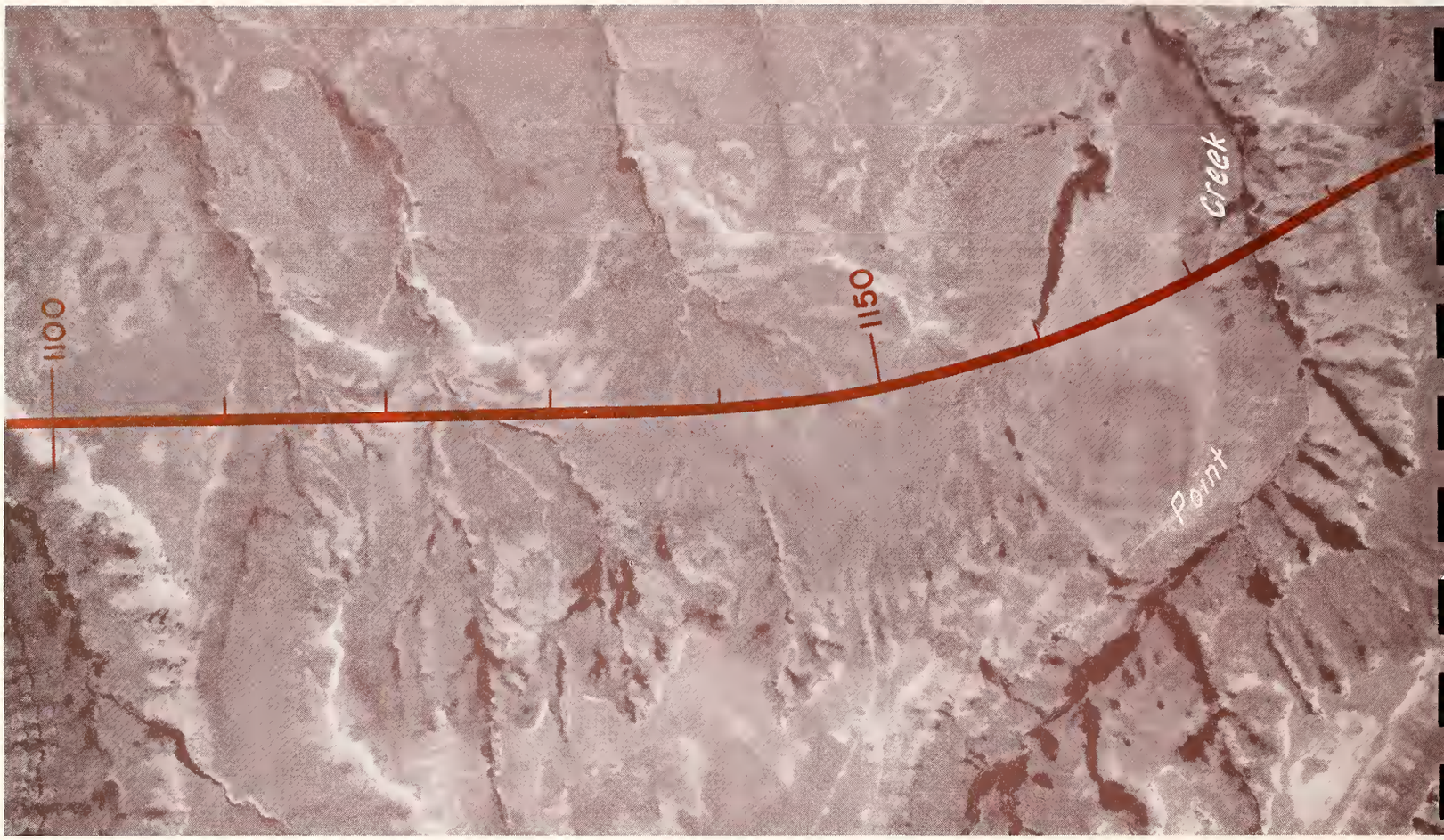
4400
4300
4200
920
930
940
950
960
970
980
-3.25%
800'
+1.75%
800'
-0.75%
800'
+3.05%

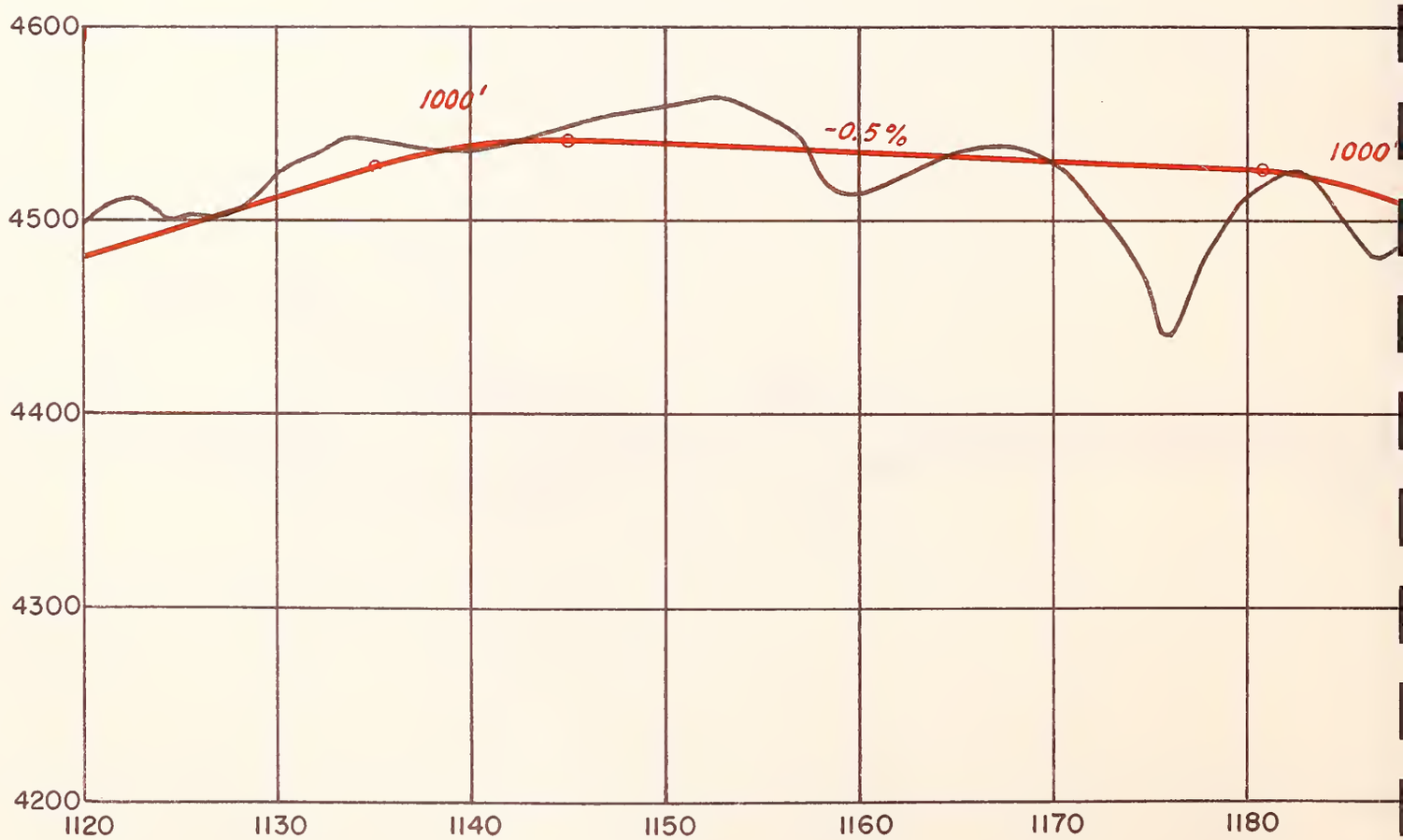
1050
Creek
Fork Buster
1000
Middle
East Fork Buster Creek

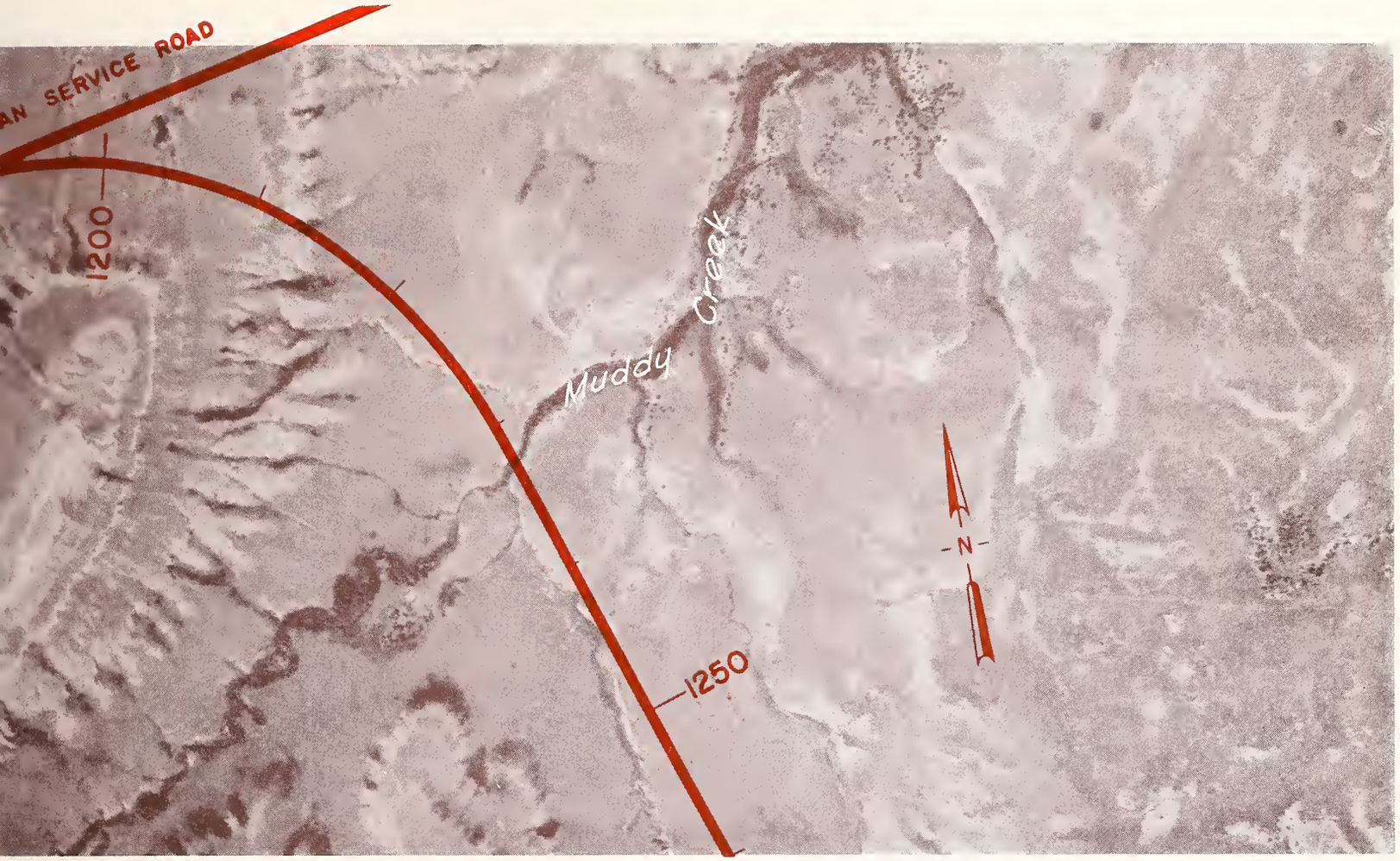

4600
4500
4400
4300
4200
980
990
1000
1010
1020
1030
1040
1000'
800'
800'
-2.5%
+3.0%
-0.5%

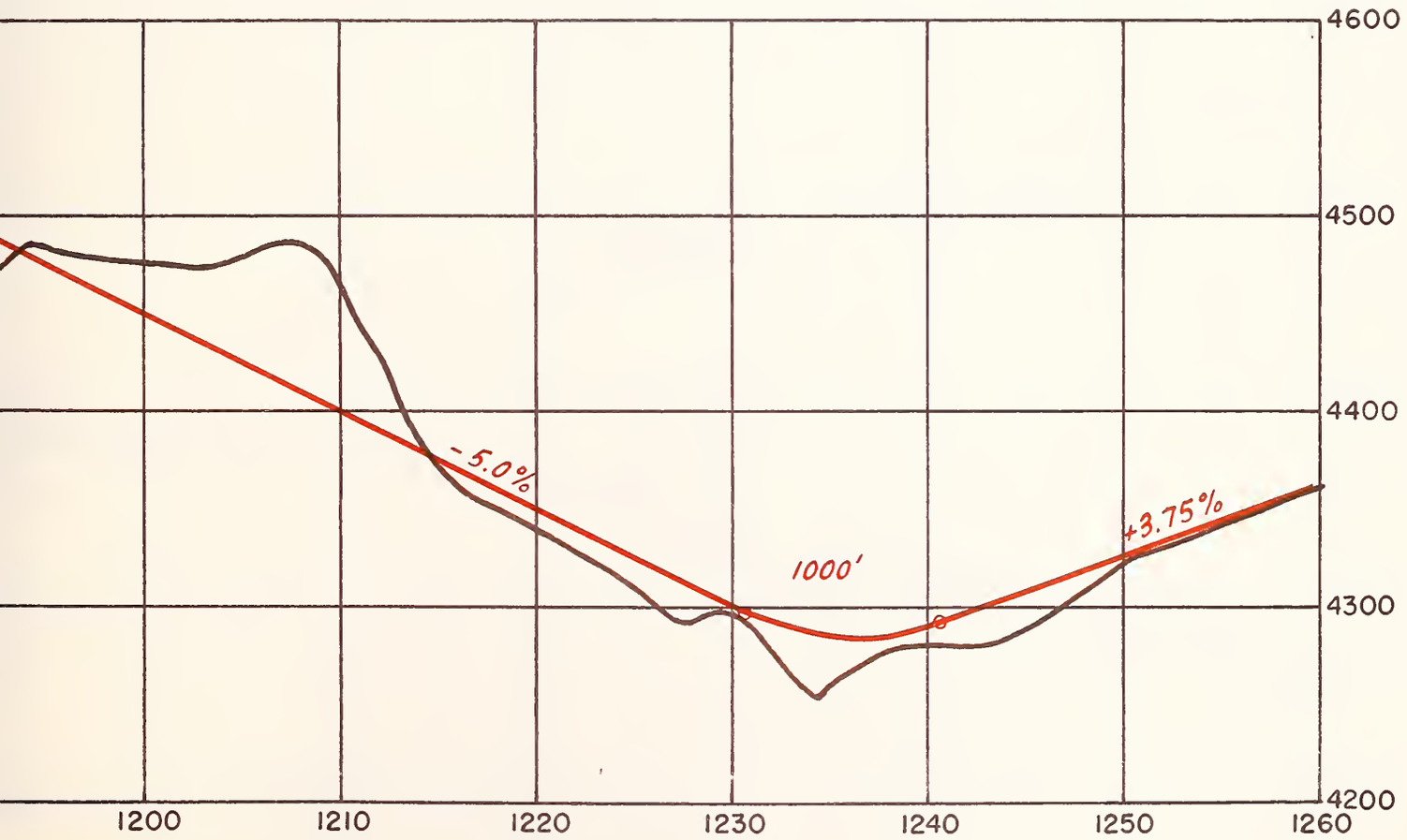

1100
Horse Coulee
N

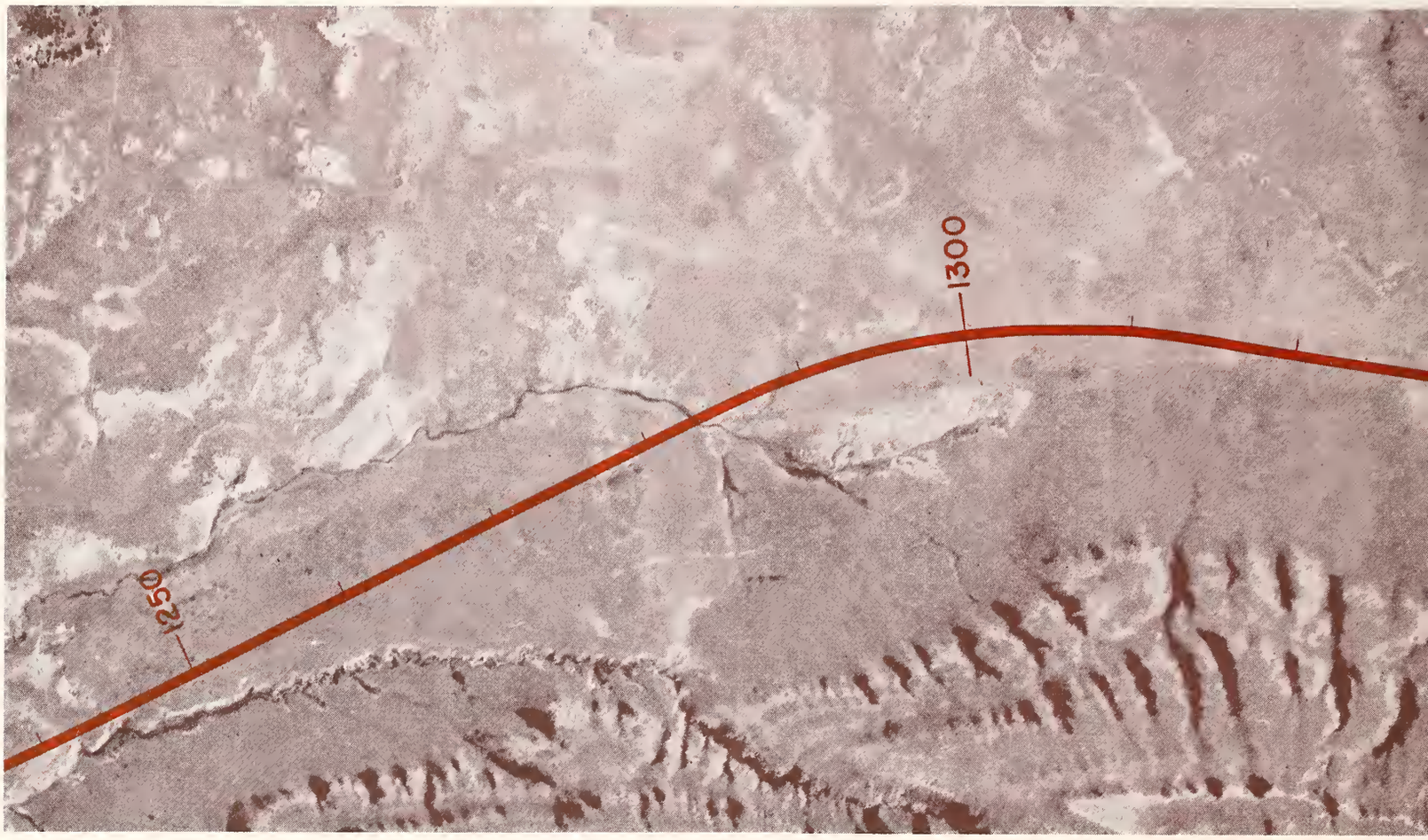

4600
4500
4400
4300
4200
1060
1070
1080
1090
1100
1110
1120
-0.5%
800'
+3.0%

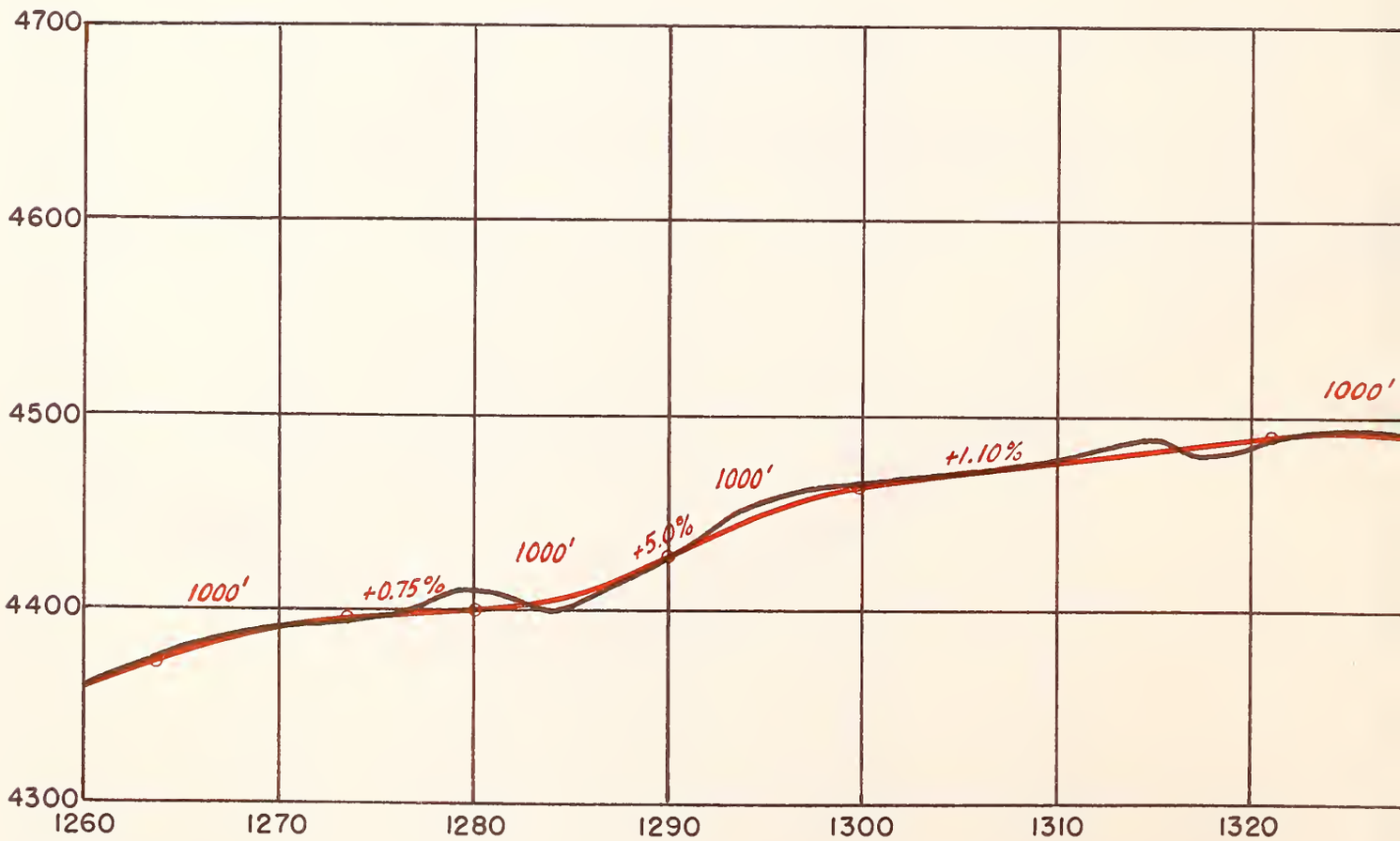

1100
1150
Creek
Point


4600
4500
4400
4300
4200
1120
1130
1140
1150
1160
1170
1180
1000'
-0.5%
1000'

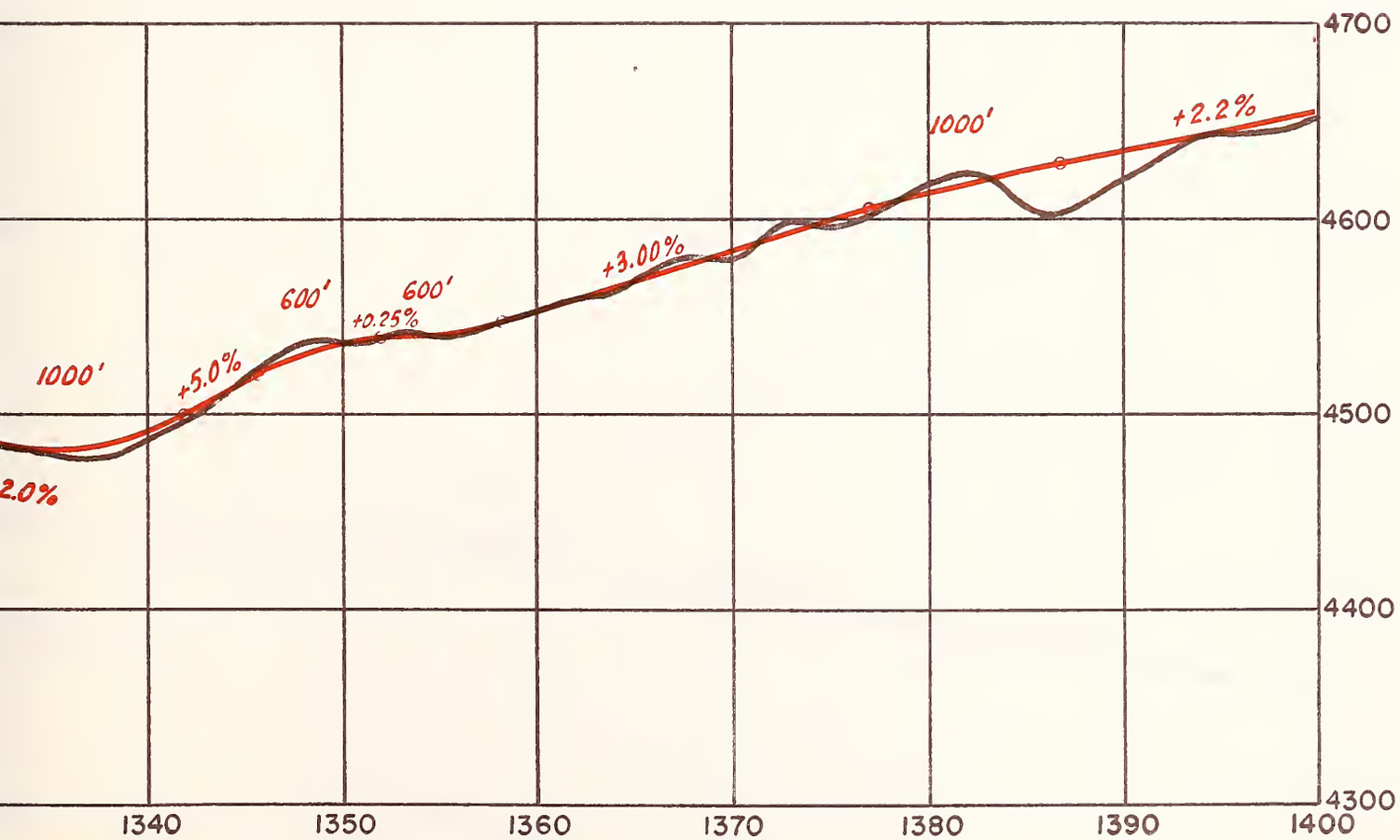

AN SERVICE ROAD
1200
Muddy Creek
N
1250

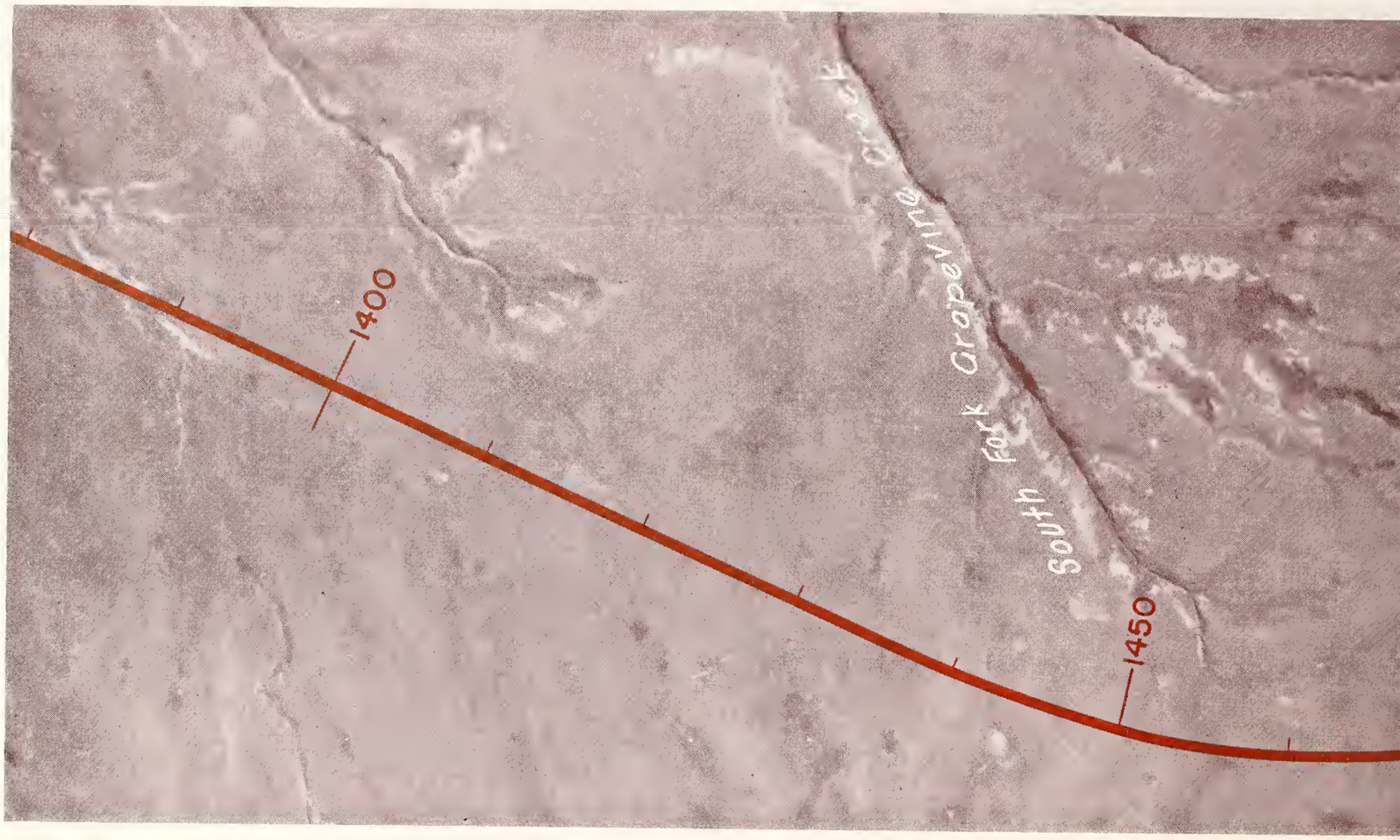

4600
4500
4400
4300
4200
-5.0%
1000'
+3.75%
1200
1210
1220
1230
1240
1250
1260

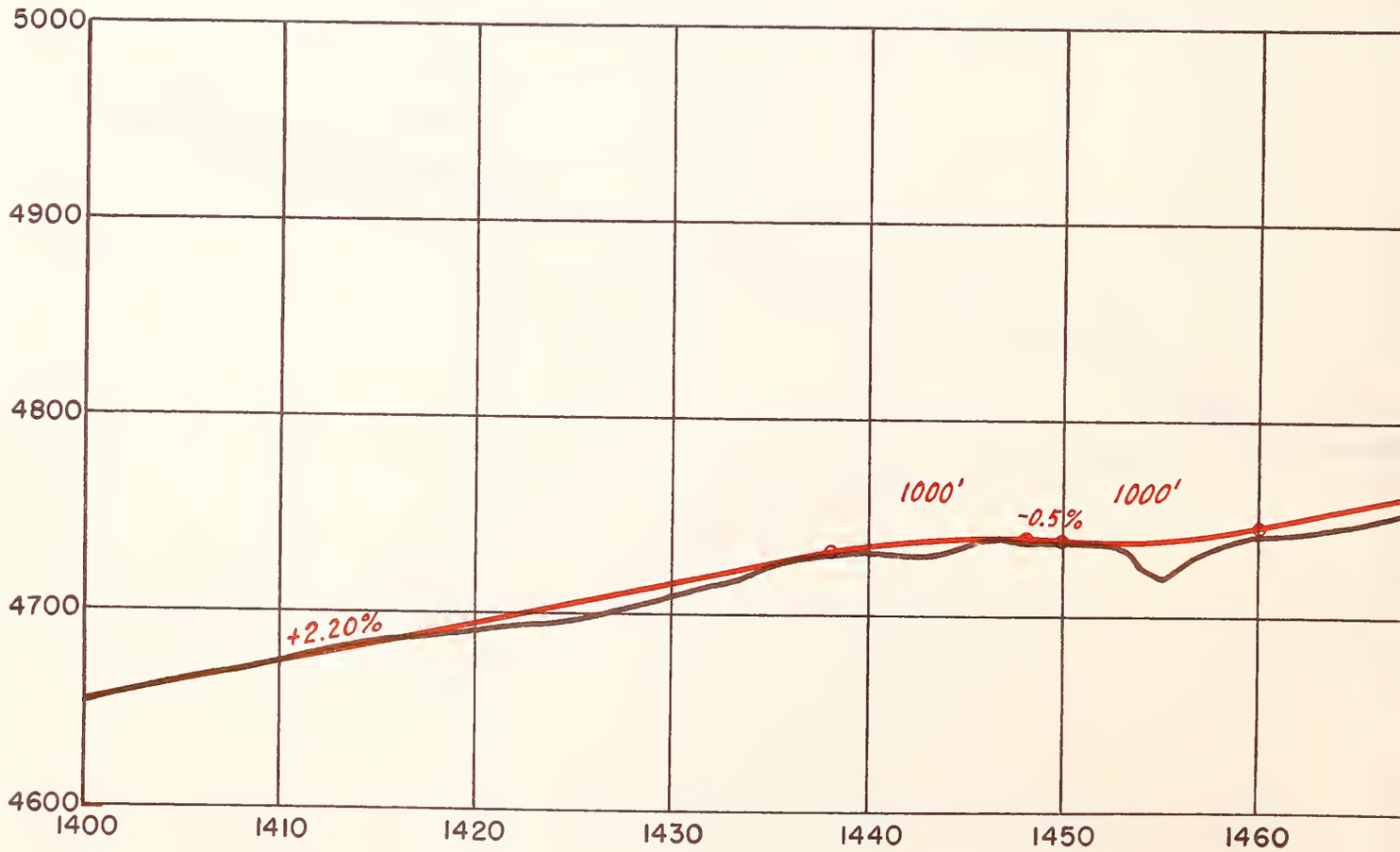

1300
1250

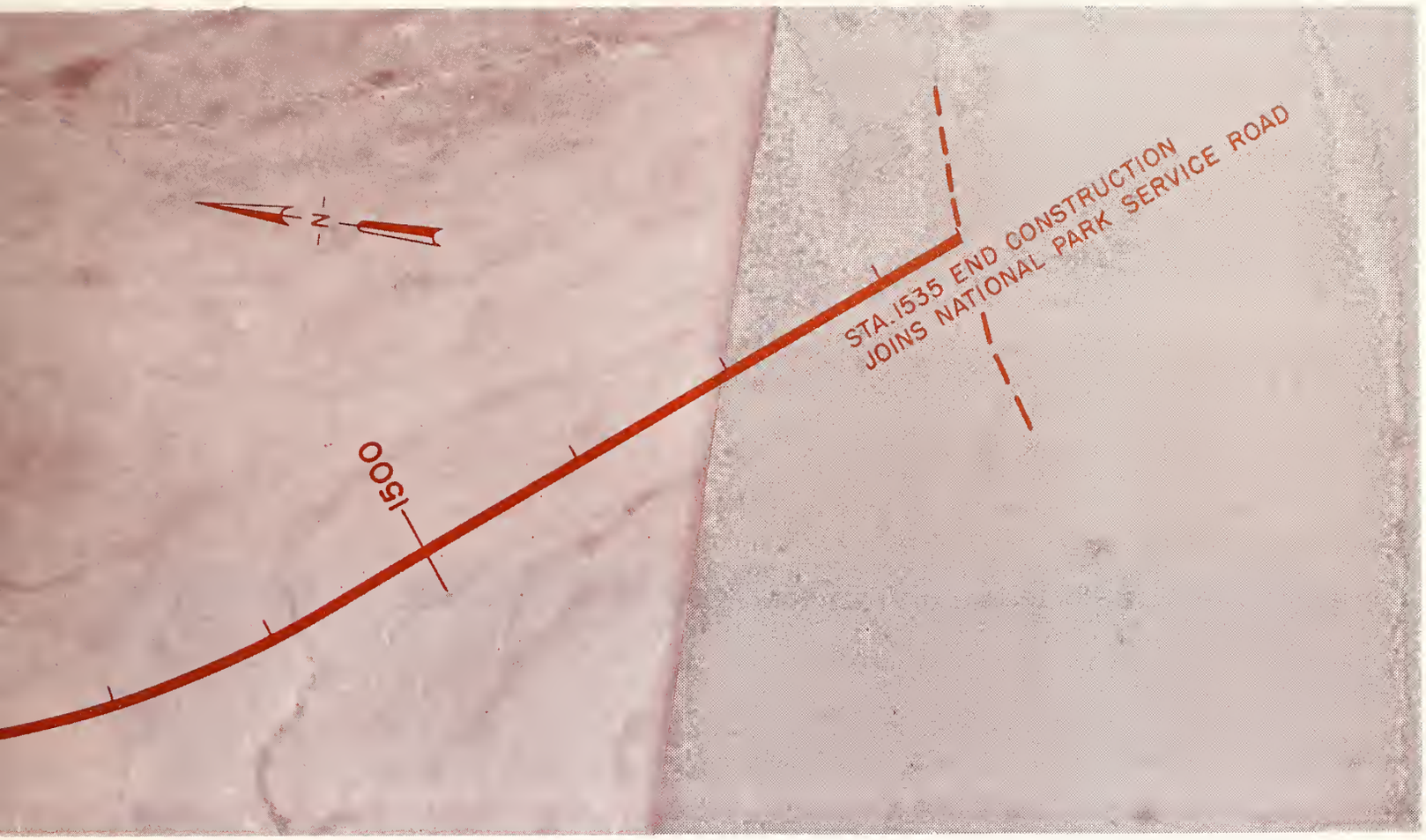

4700
4600
4500
4400
4300
1260
1270
1280
1290
1300
1310
1320
1000'
+0.75%
1000'
+5.0%
1000'
+1.10%
1000'

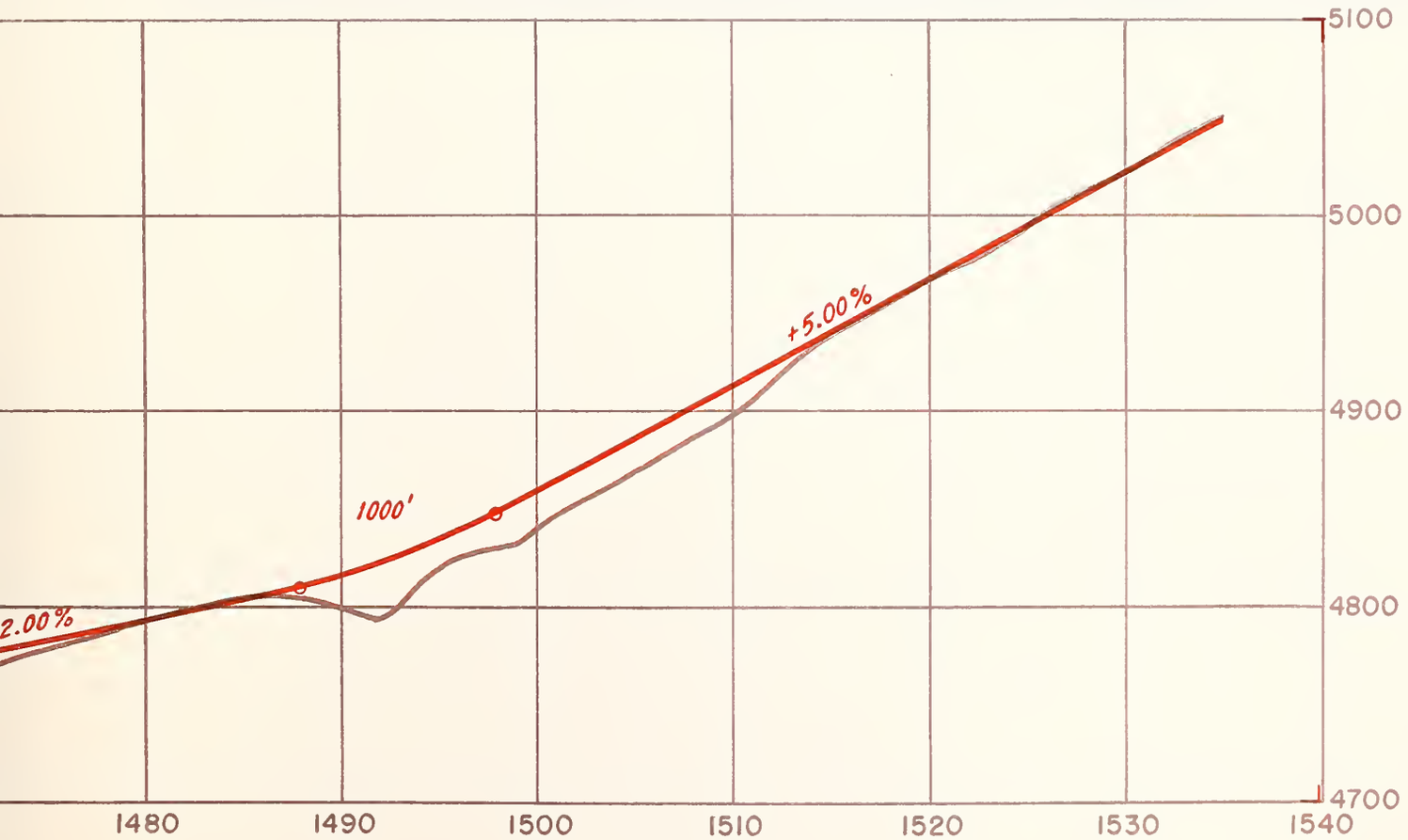
1350
1400
N


4700
4600
4500
4400
4300
1340
1350
1360
1370
1380
1390
1400
1000'
+5.0%
600'
+0.25%
600'
+3.00%
1000'
+2.2%
2.0%


1400
South fork Grapevine Creek
1450


5000
4900
4800
4700
4600
1400
1410
1420
1430
1440
1450
1460
1000'
-0.5%
1000'
+2.20%


N
STA. 1535 END CONSTRUCTION
JOINS NATIONAL PARK SERVICE ROAD
1500

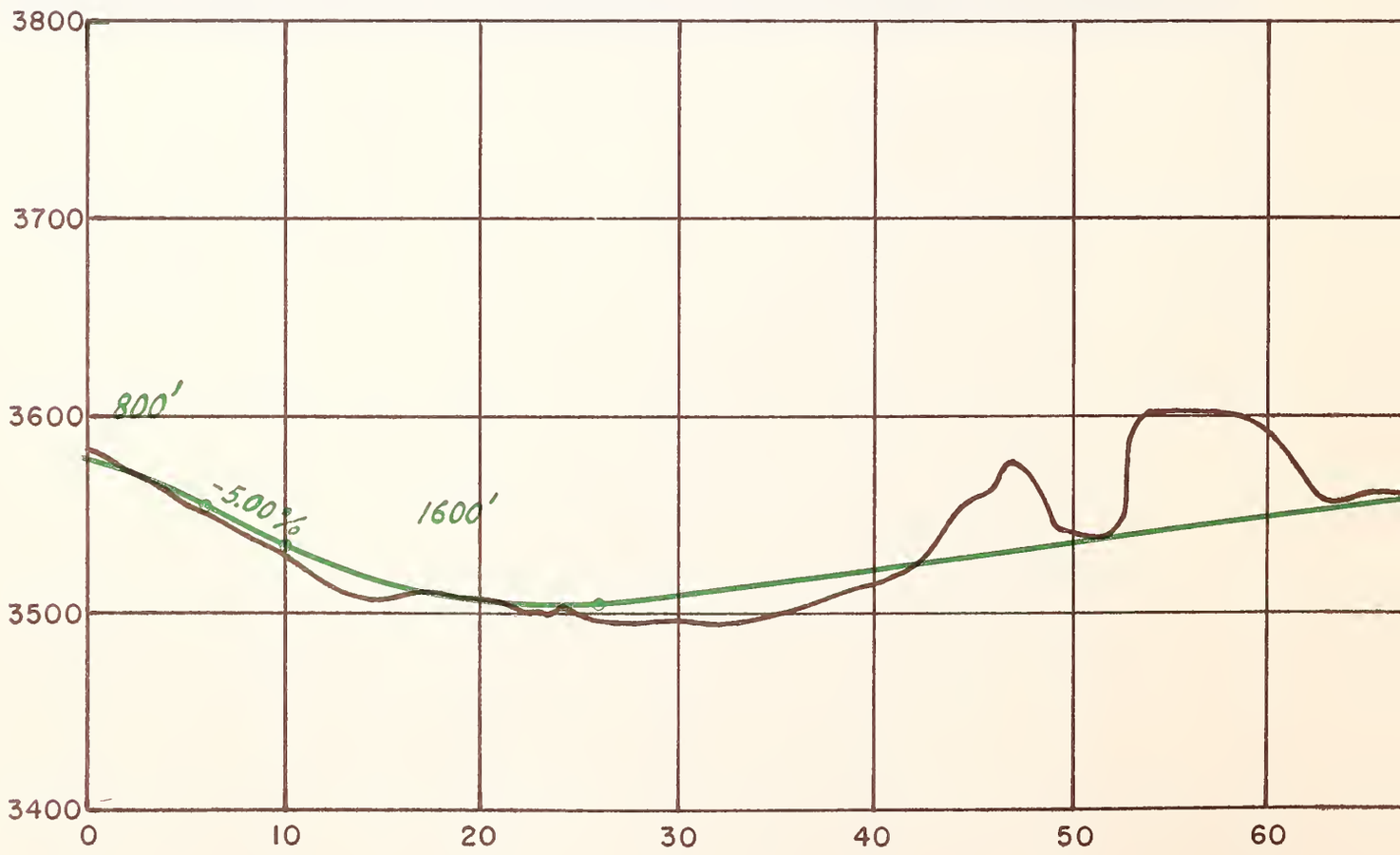

5100
5000
4900
4800
4700
+5.00%
1000'
2.00%
1480
1490
1500
1510
1520
1530
1540

Alternate No. 2

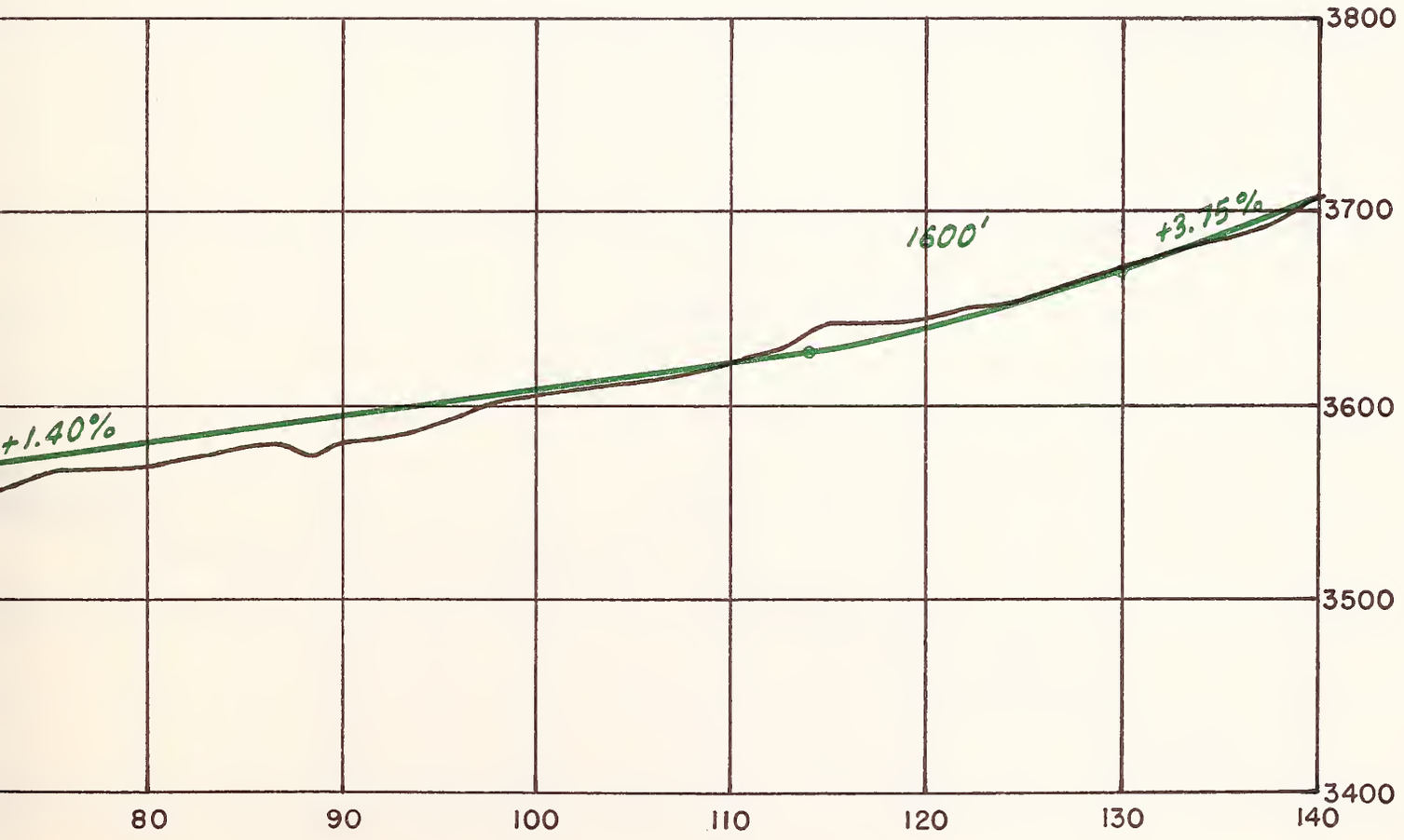
PLAN & PROFILE SHEETS

New Construction Only

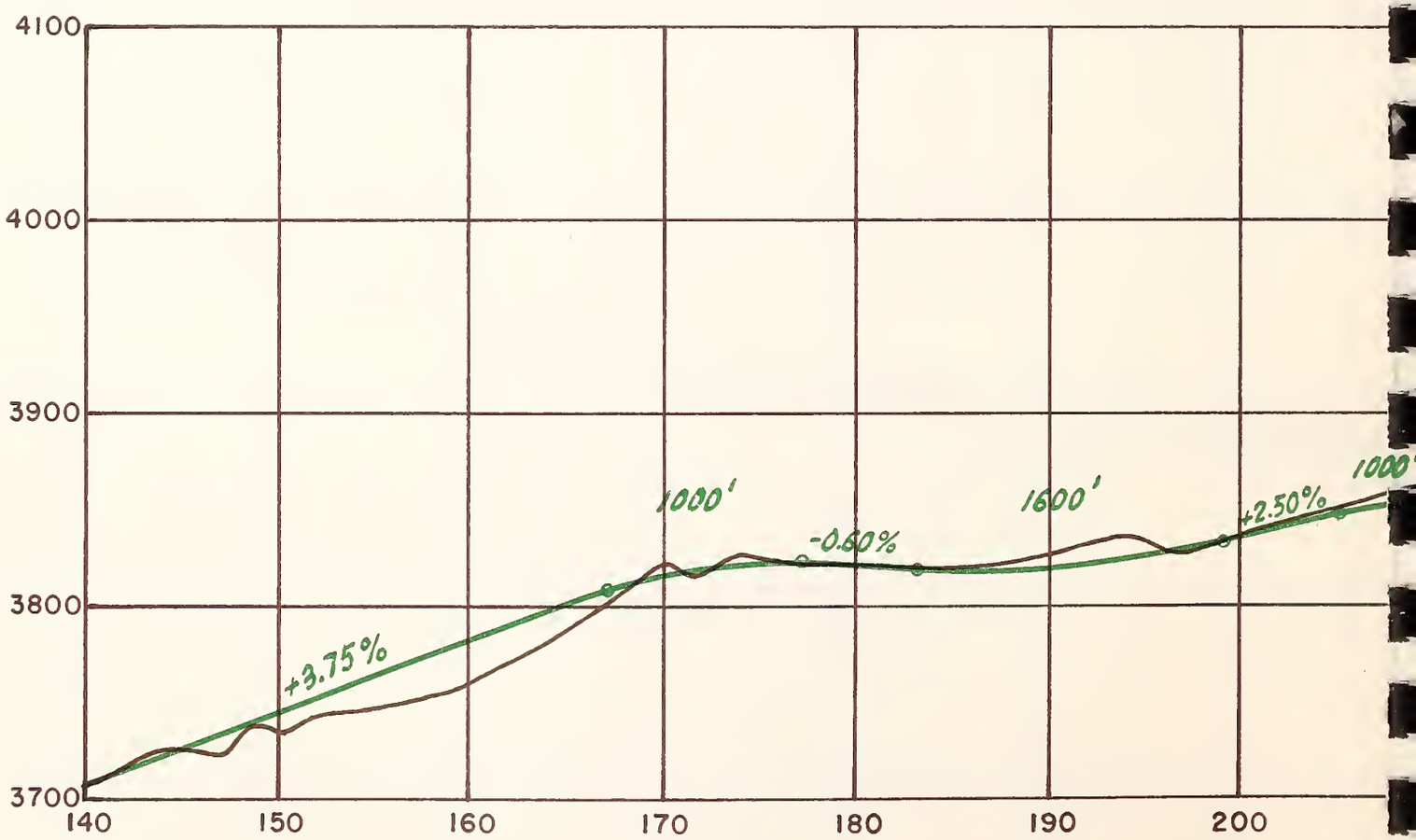
STA. 0+00
BEGIN CONSTRUCTION
BLUE CREEK ROAD
ROAD
50
Wets Creek
Creek
Pryor
Pryor


3800
3700
3600
3500
3400
800'
-5.00%
1600'
0
10
20
30
40
50
60

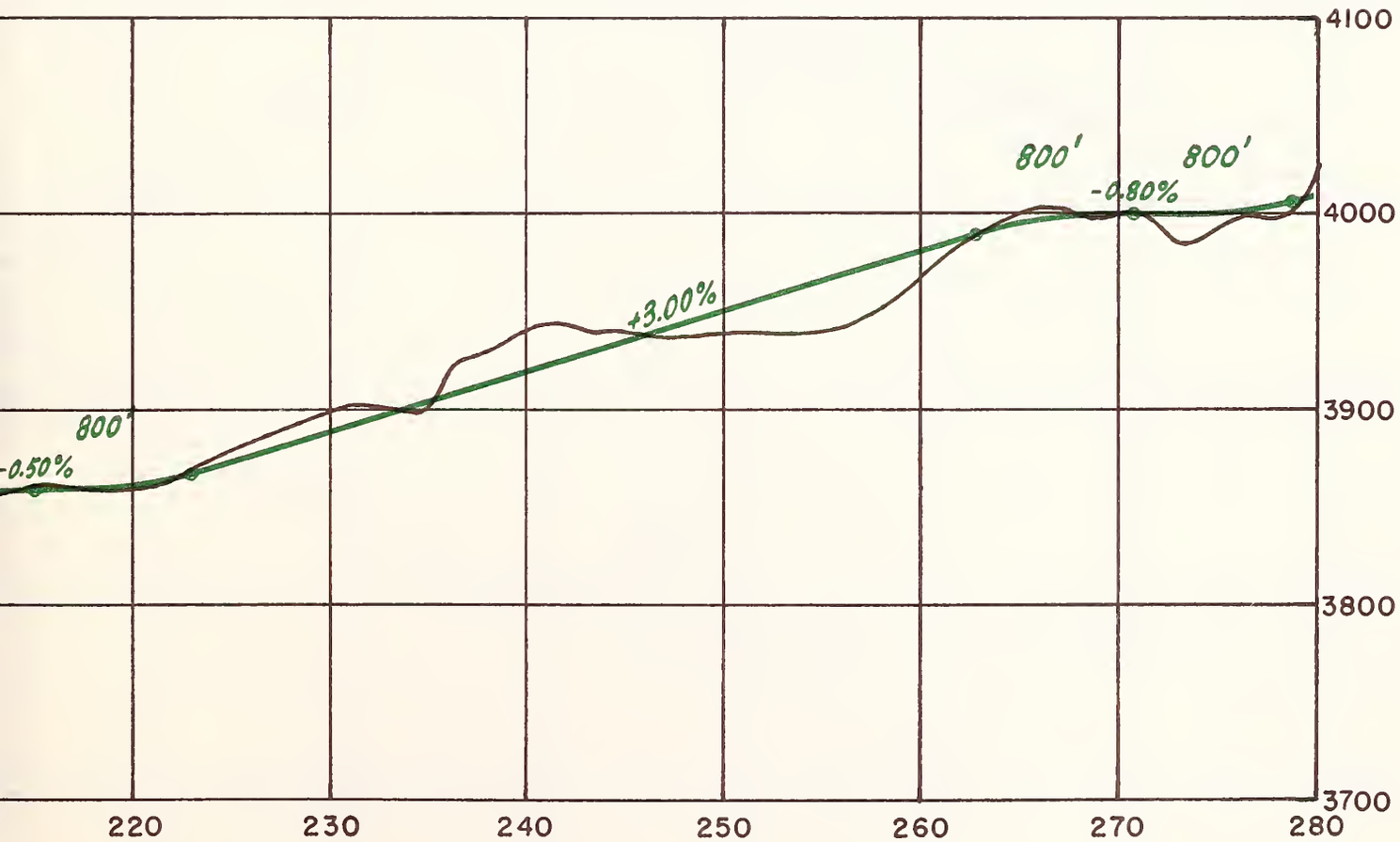
N
100
150
East
Creek


3800
3700
3600
3500
3400
80
90
100
110
120
130
140
+1.40%
1600'
+3.75%

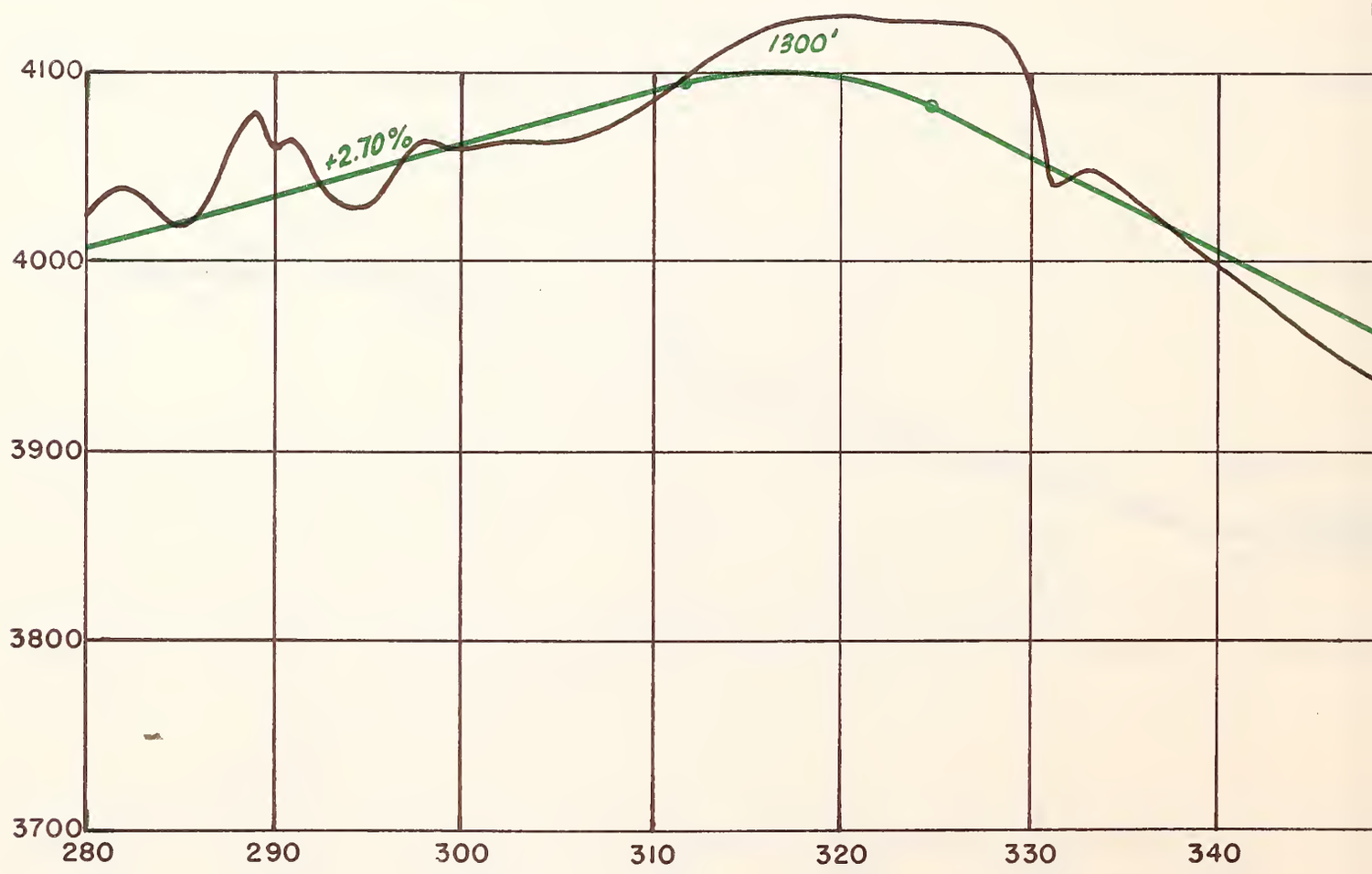
150
East
Wets
Creek
200


4100
4000
3900
3800
3700
140
150
160
170
180
190
200
1000'
+3.75%
-0.60%
1600'
+2.50%
1000'

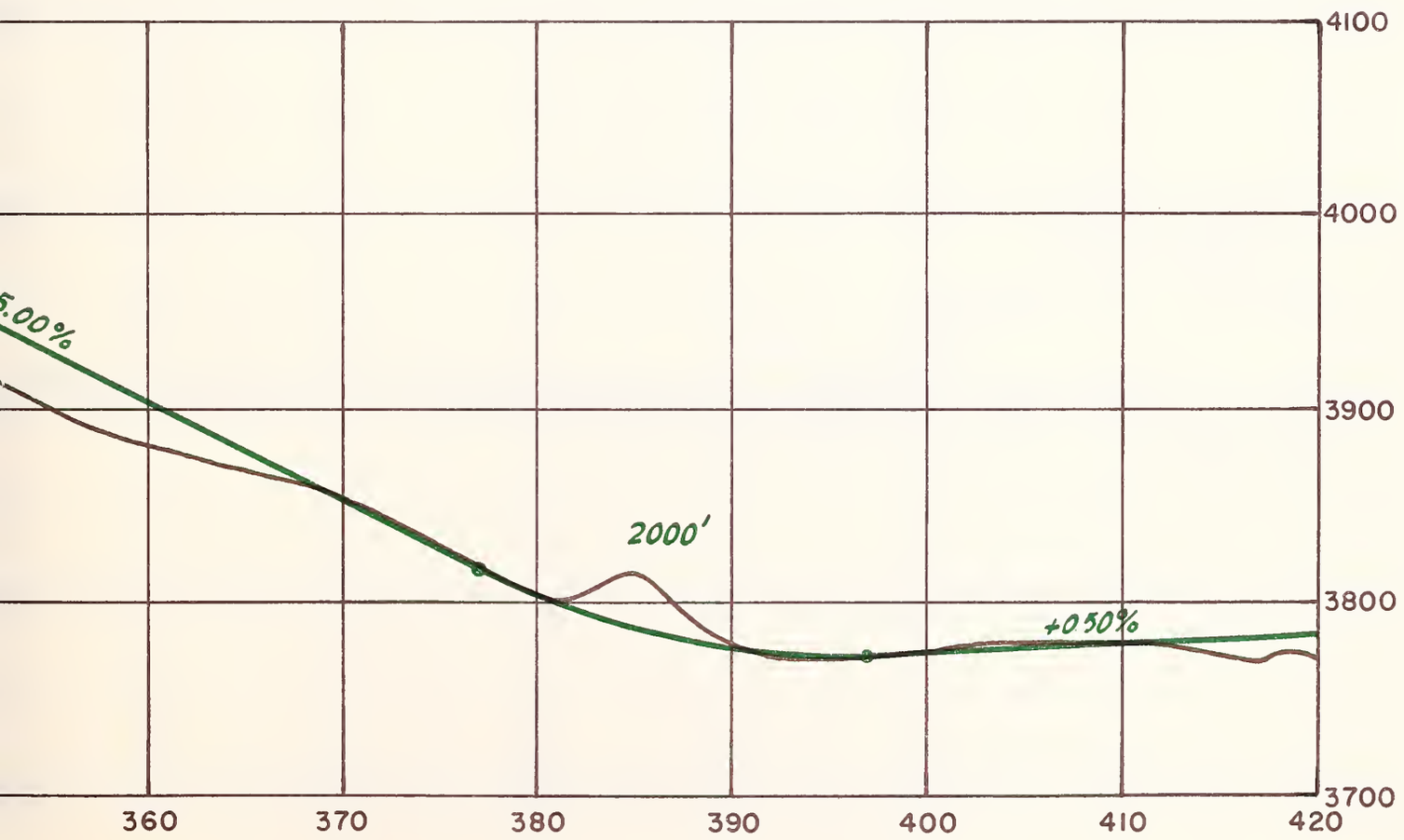
N
250
300


4100
4000
3900
3800
3700
800'
800'
-0.80%
+3.00%
800'
-0.50%
220
230
240
250
260
270
280

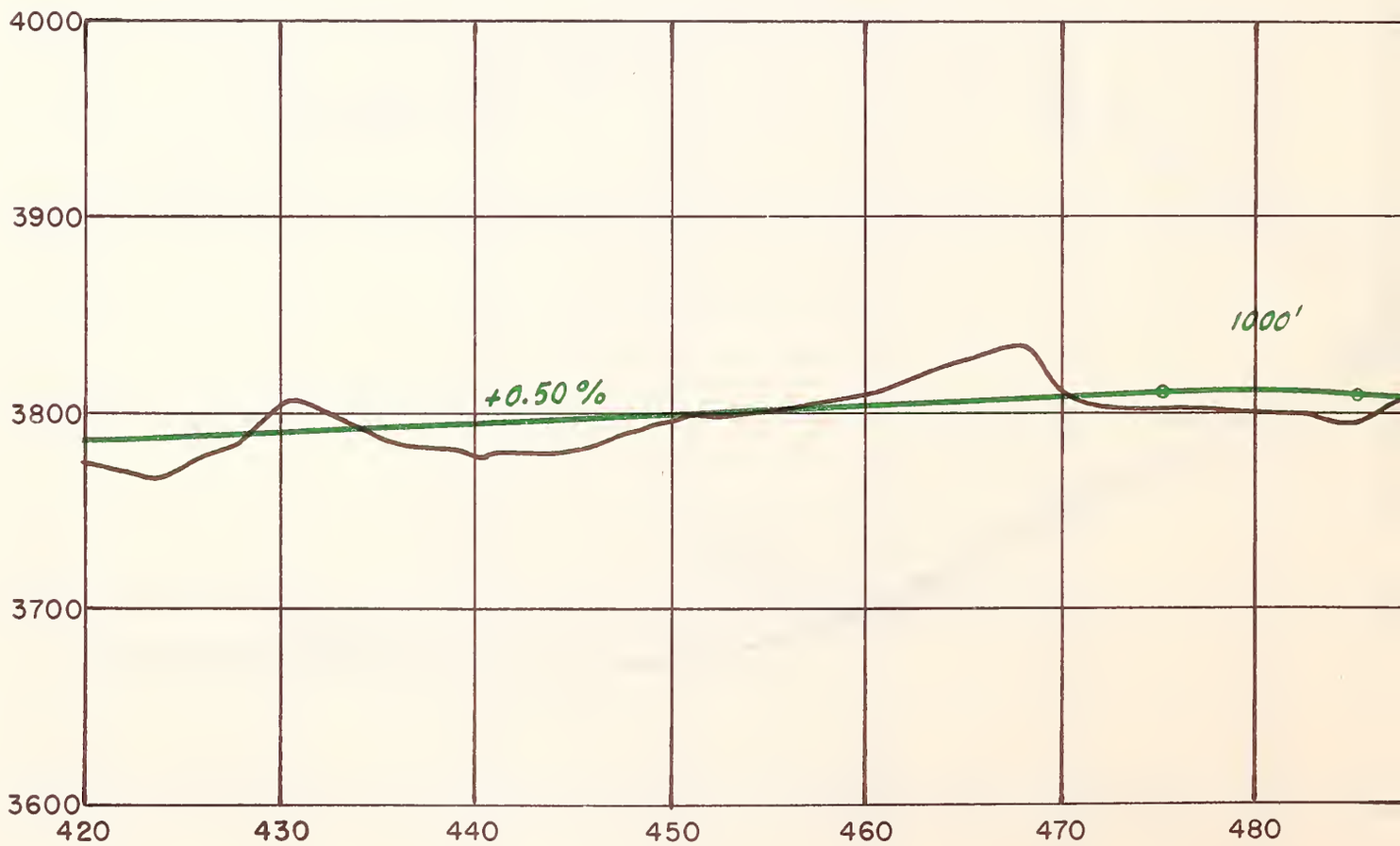
N
300
350
East
Wets
Creek


1300'
+2.70%
4100
4000
3900
3800
3700
280
290
300
310
320
330
340

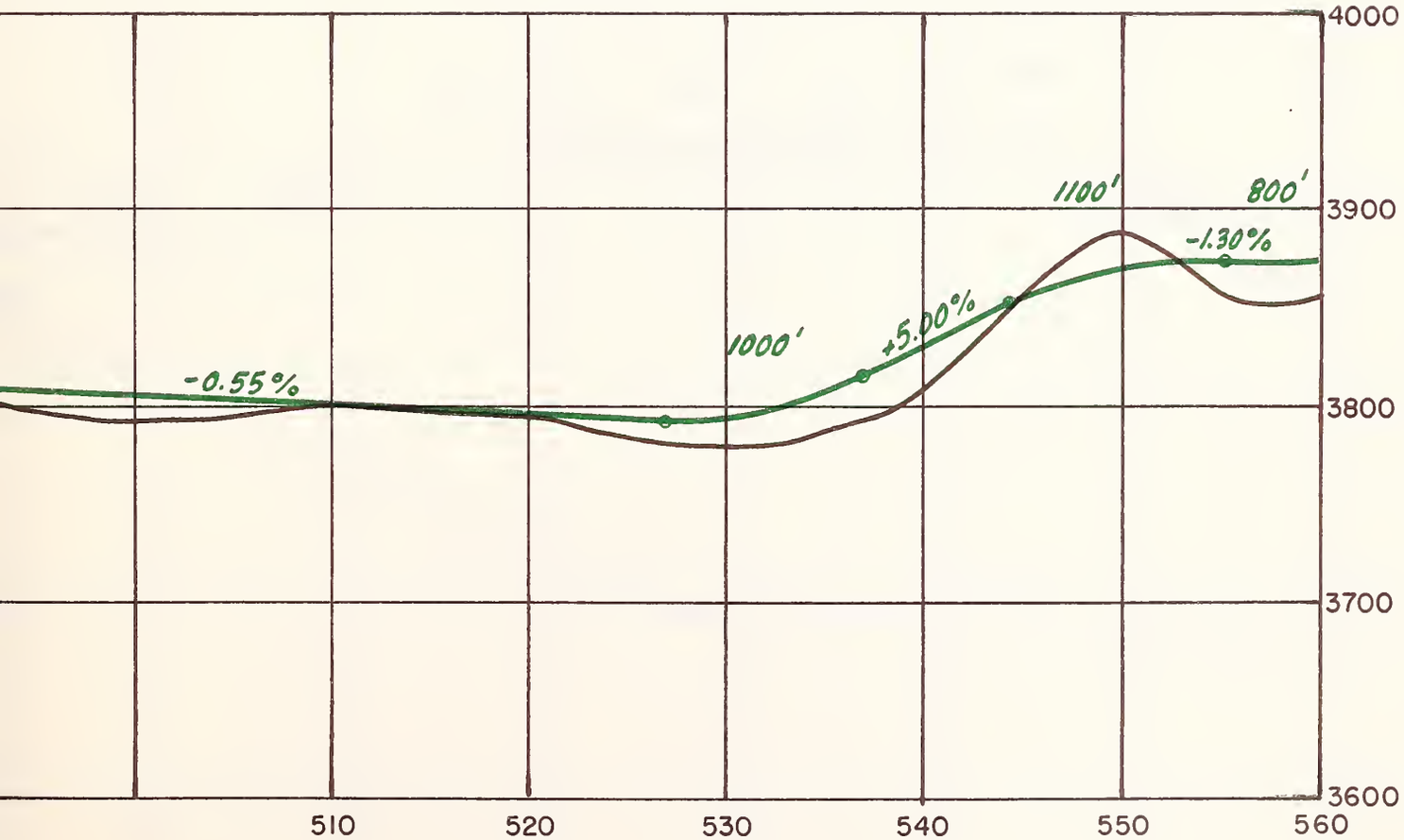
400
East Fork Creek


4100
4000
3900
3800
3700
5.00%
2000'
+0.50%
360
370
380
390
400
410
420

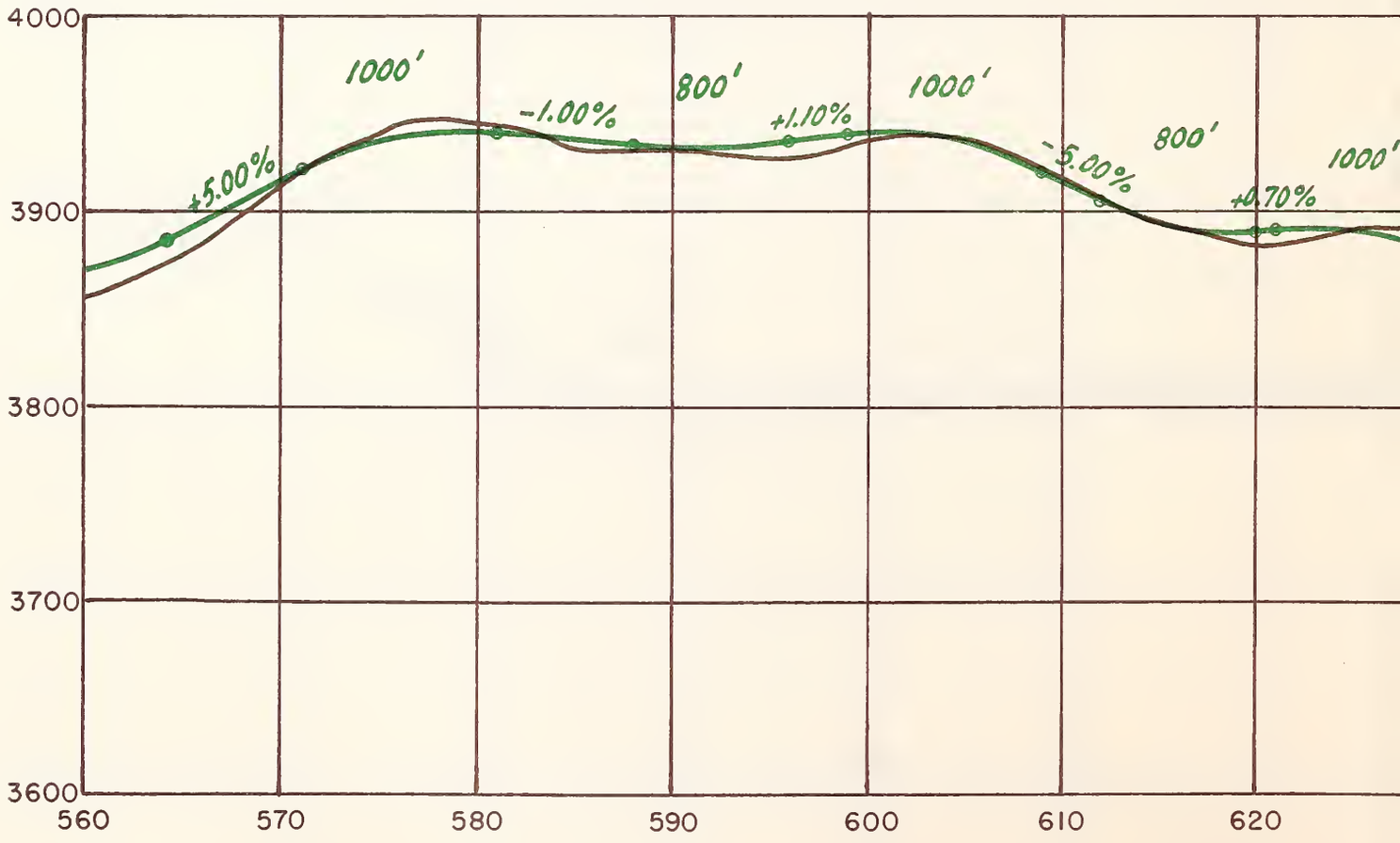
400
East Fork
Creek
450


4000
3900
3800
3700
3600
420
430
440
450
460
470
480
+0.50 %
1000'

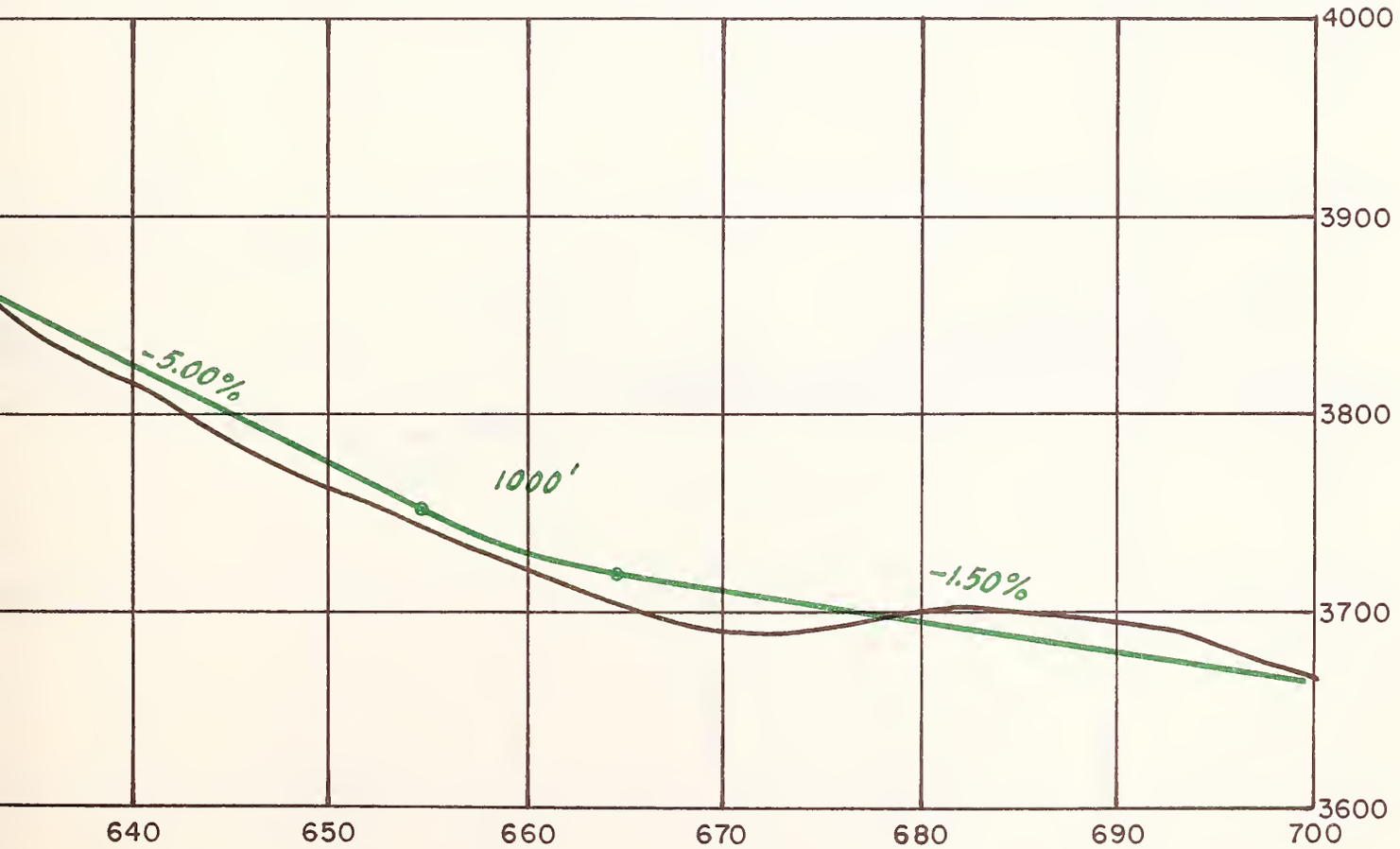
N
500
550
Flat Creek


4000
3900
3800
3700
3600
510
520
530
540
550
560
-0.55%
1000'
+5.00%
1100'
800'
-1.30%

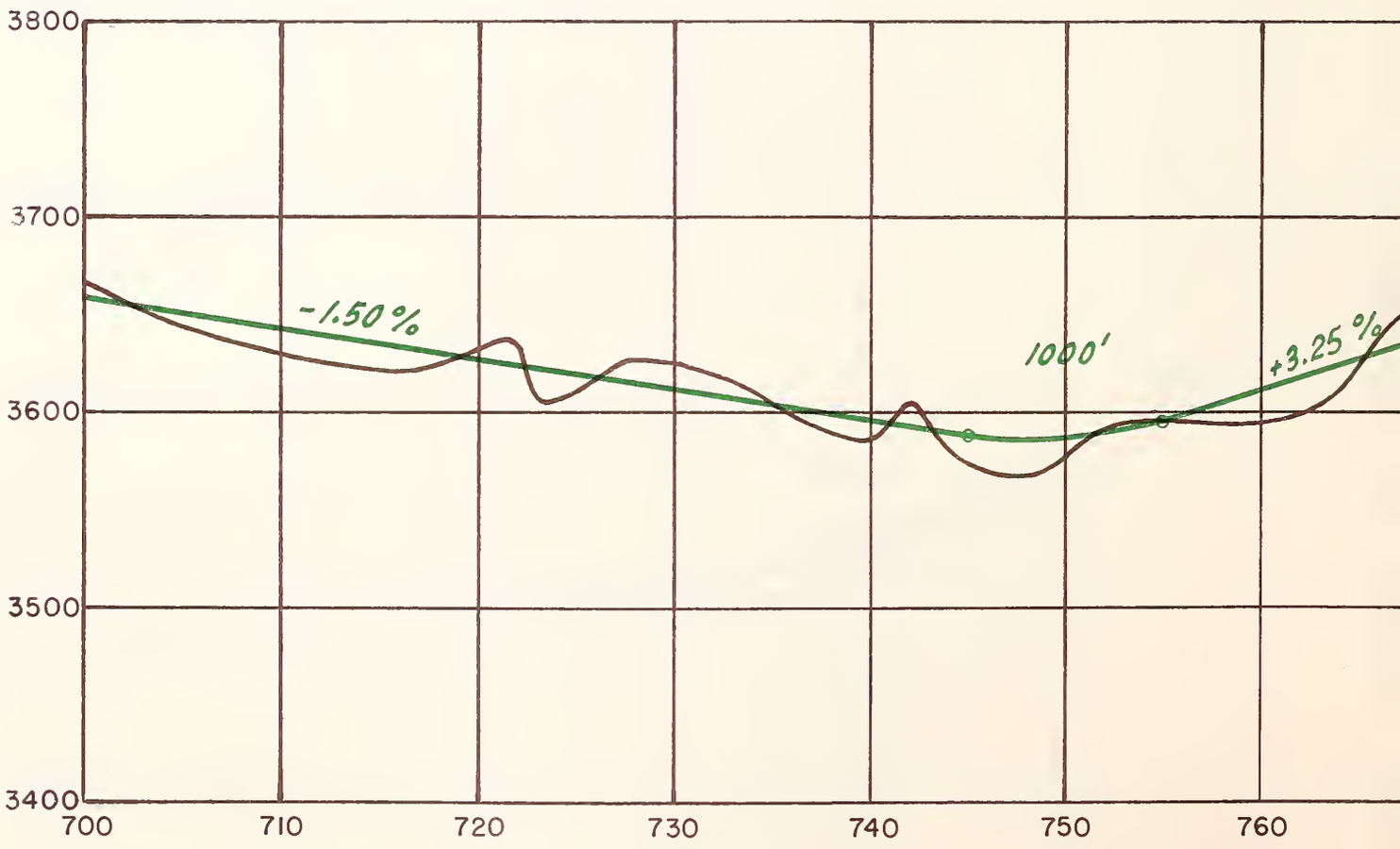
Flat creek
N
600

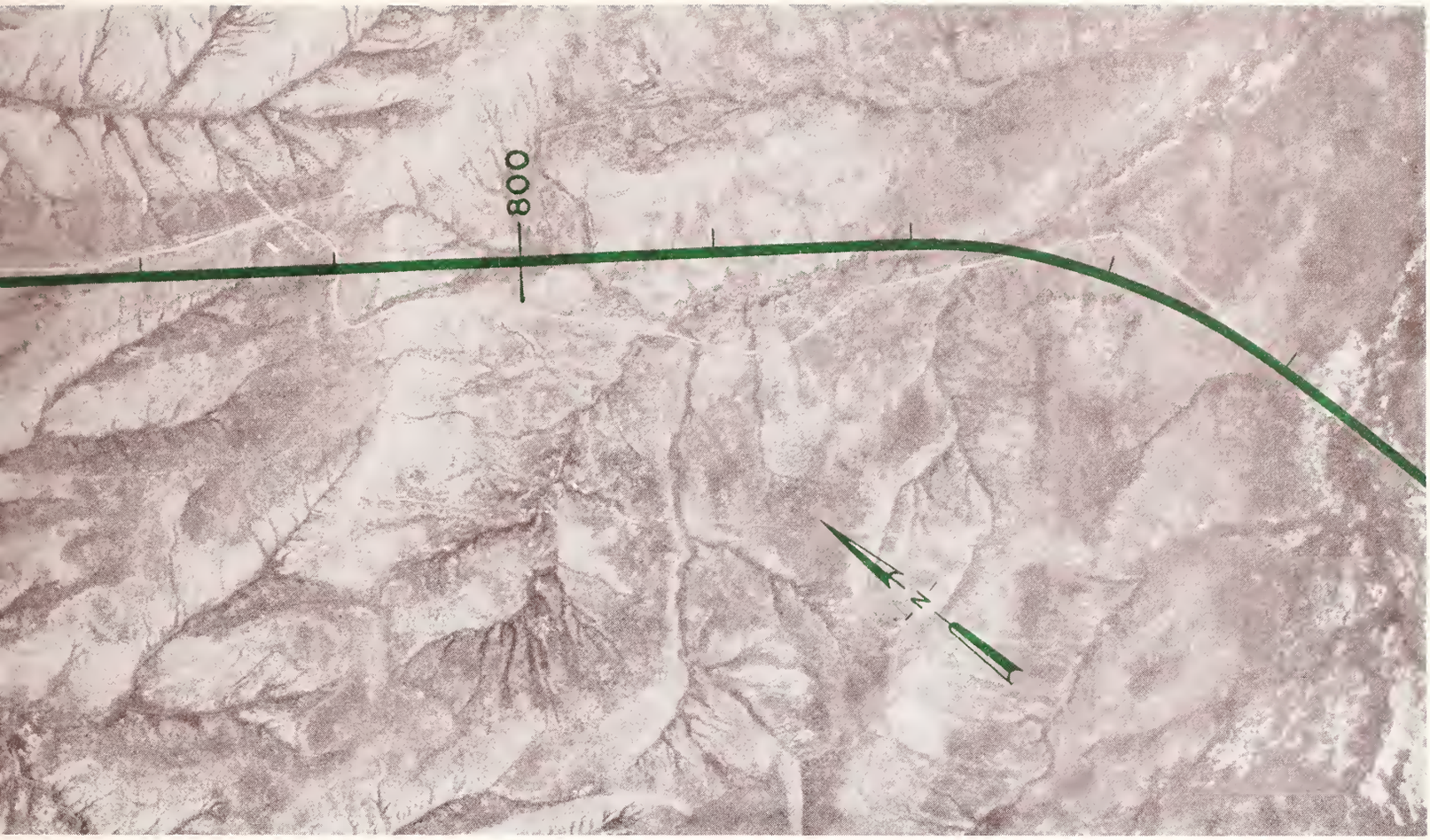

4000
3900
3800
3700
3600
560
570
580
590
600
610
620
1000'
800'
1000'
800'
1000'
+5.00%
-1.00%
+1.10%
-5.00%
+0.70%

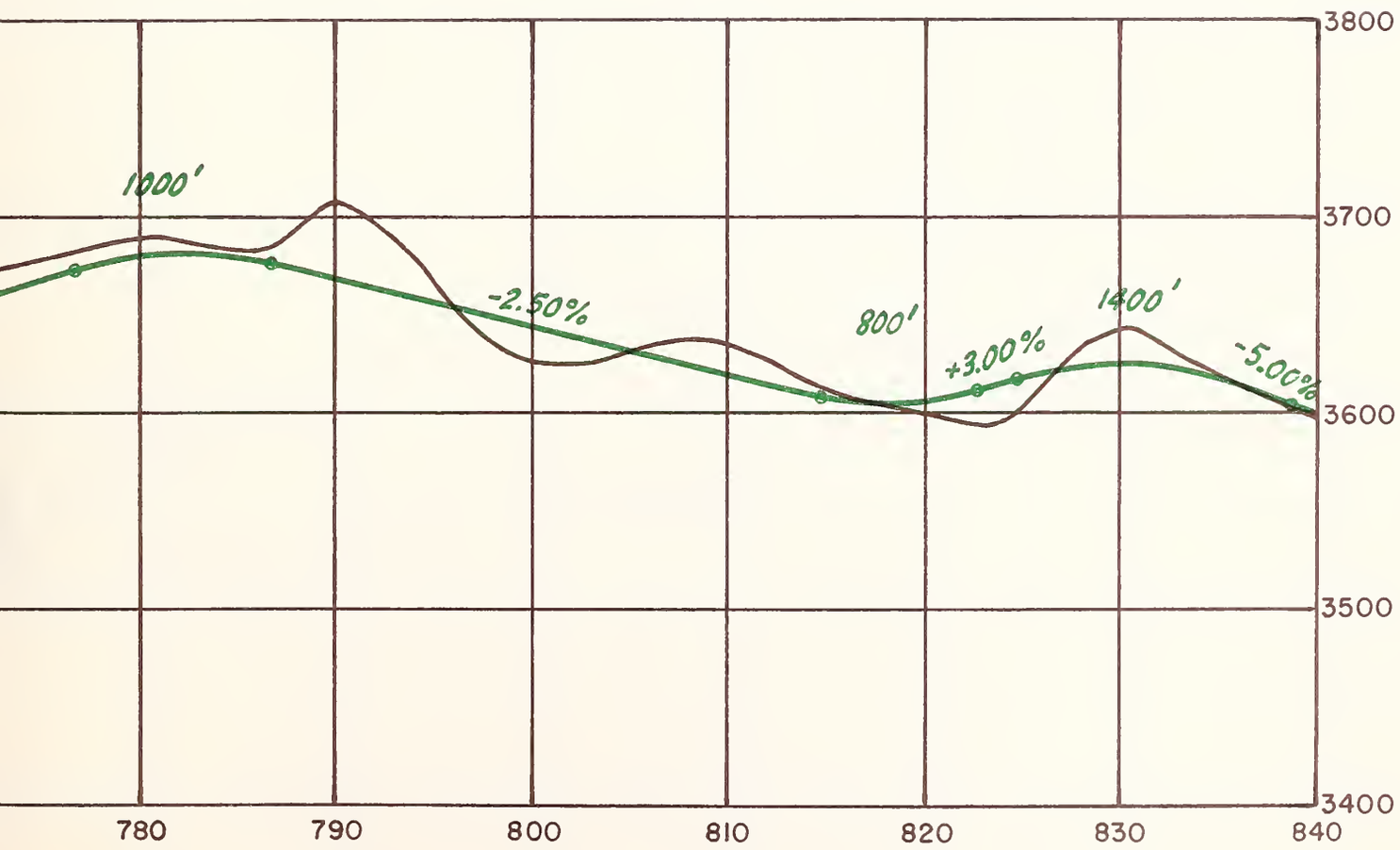
650
700


4000
3900
3800
3700
3600
-5.00%
1000'
-1.50%
640
650
660
670
680
690
700

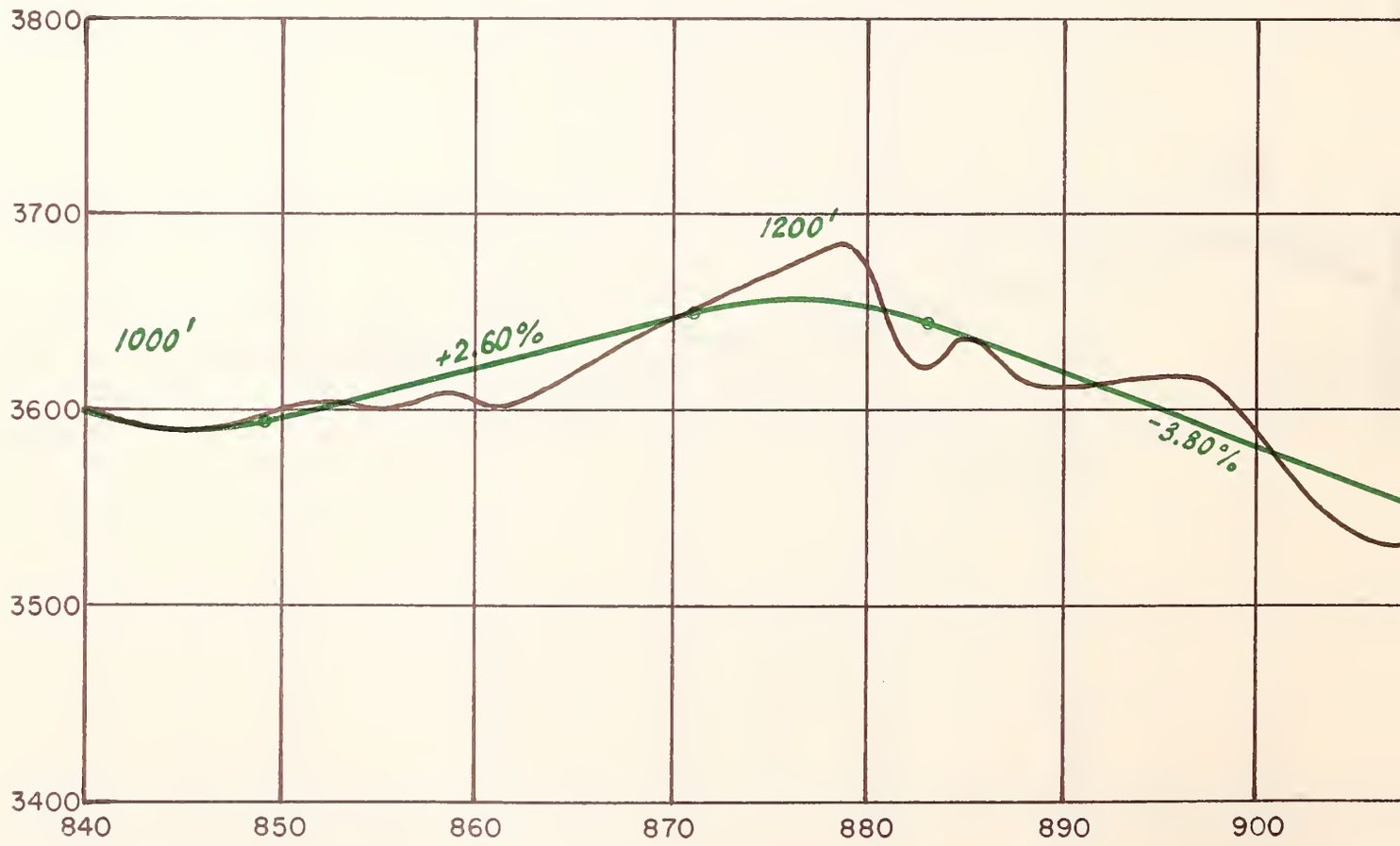
700
750
Woody
Creek


3800
3700
3600
3500
3400
700
710
720
730
740
750
760
-1.50 %
1000'
+3.25 %

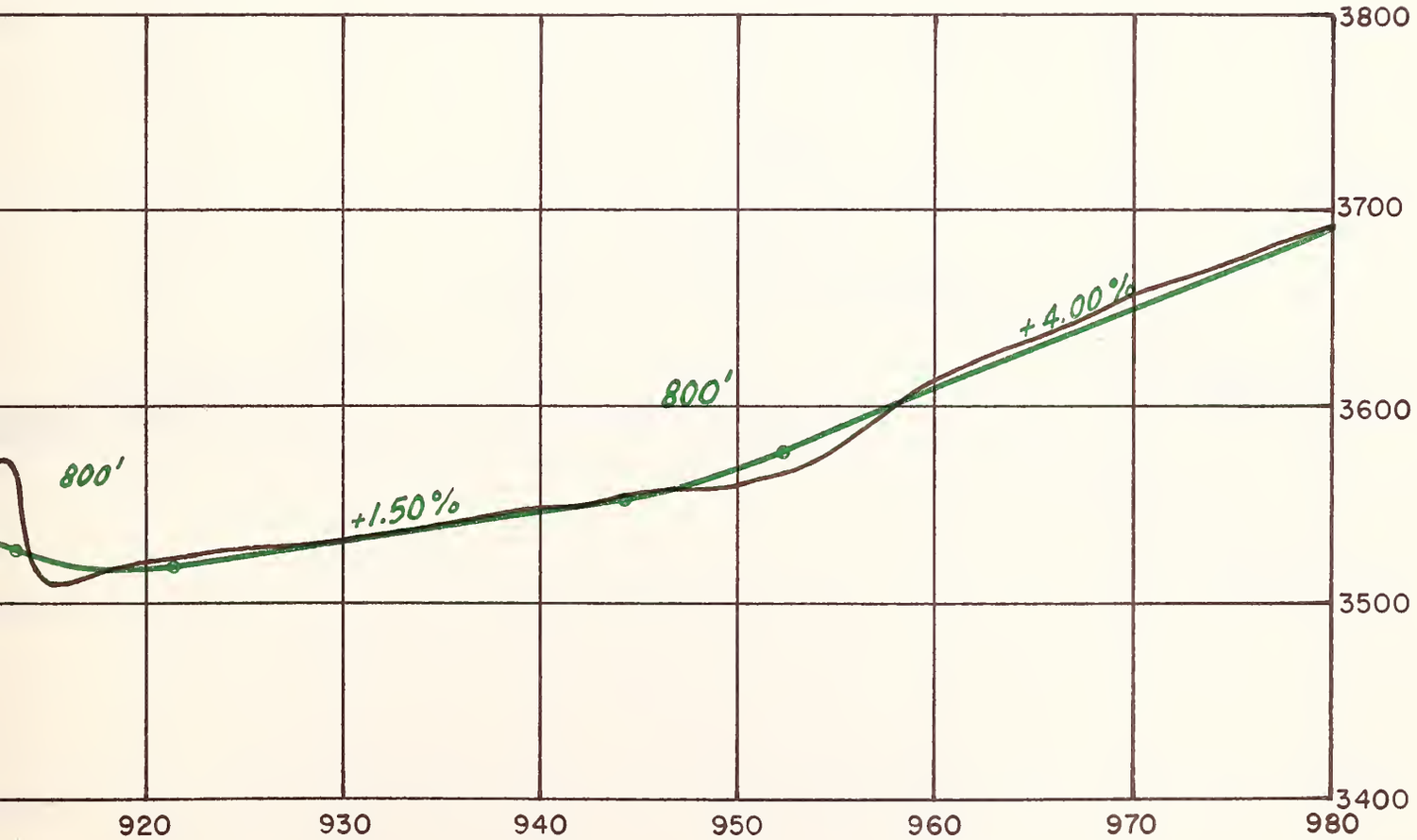

800
N


1000'
-2.50%
800'
+3.00%
1400'
-5.00%
3800
3700
3600
3500
3400
780
790
800
810
820
830
840

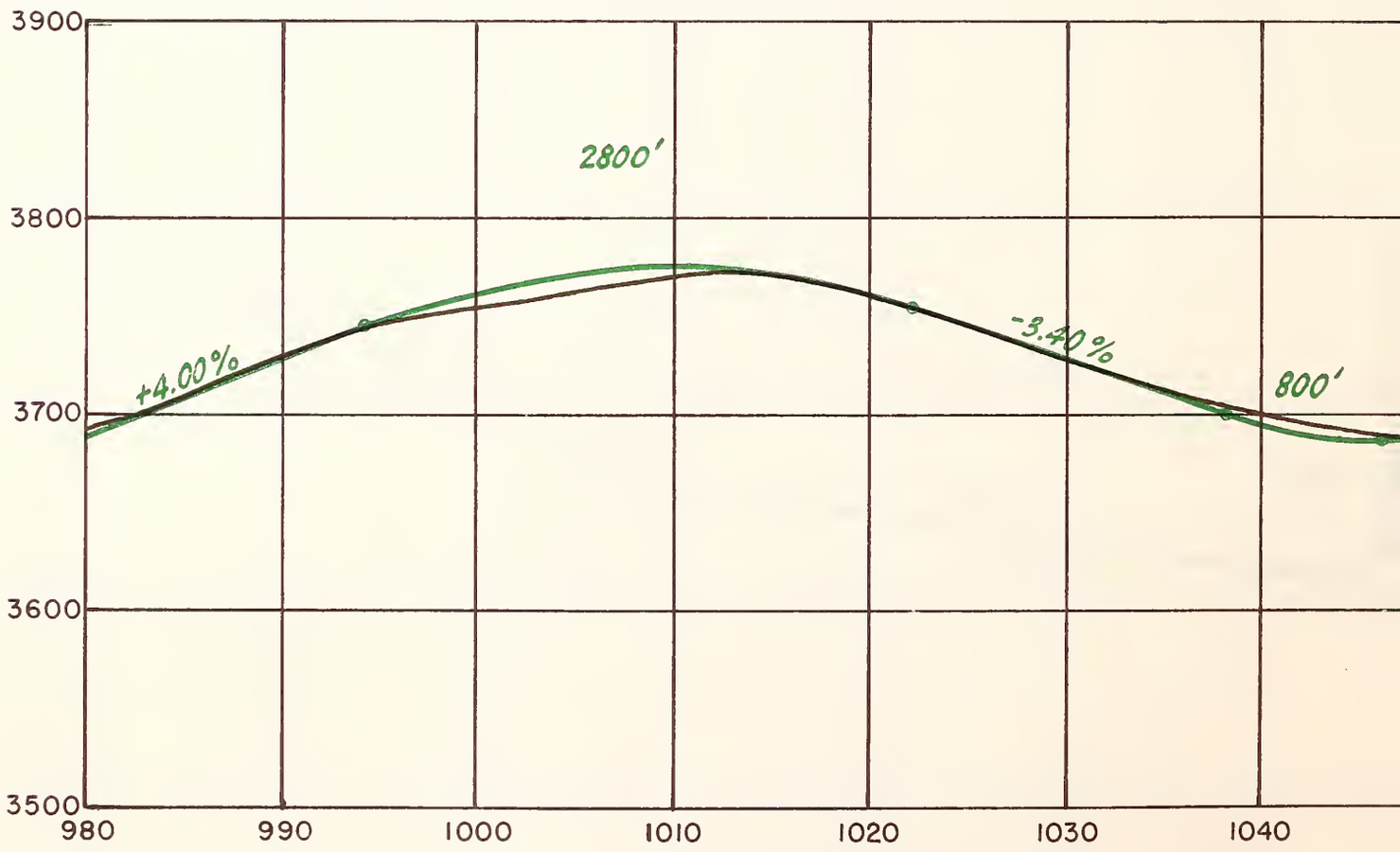
850
900


3800
3700
3600
3500
3400
840
850
860
870
880
890
900
1000'
+2.60%
1200'
-3.80%

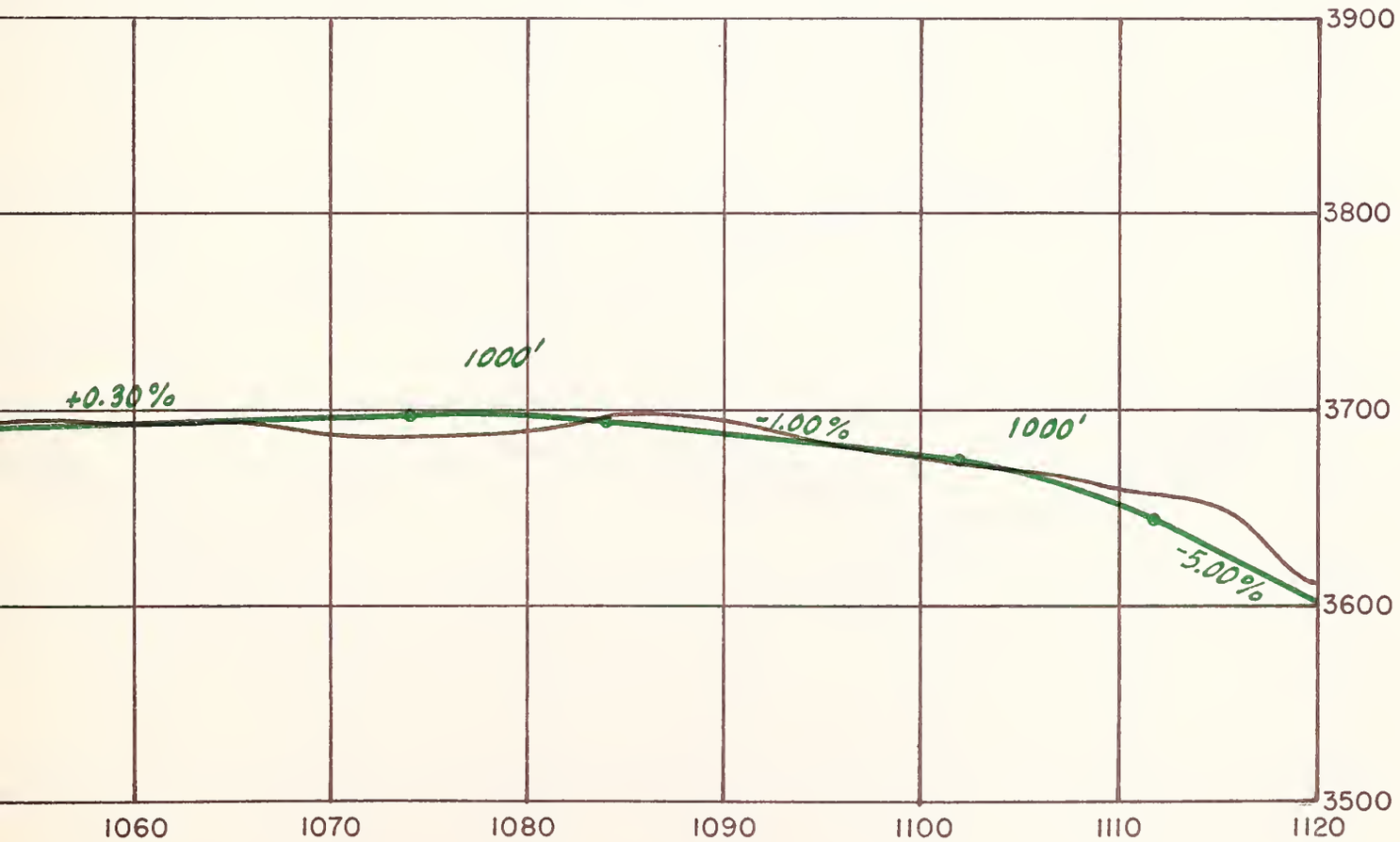
950
N

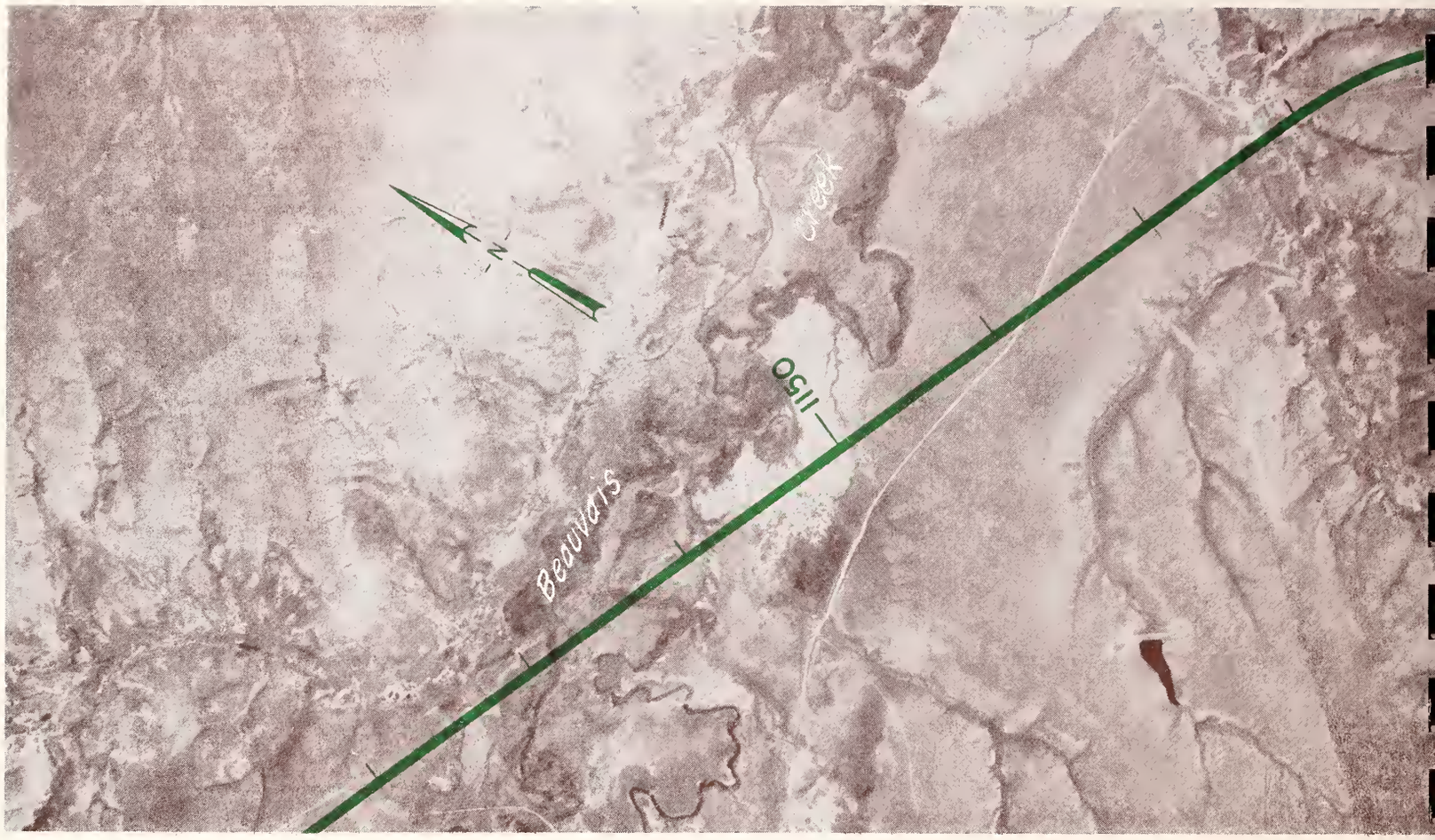

3800
3700
3600
3500
3400
920
930
940
950
960
970
980
800'
+1.50%
800'
+4.00%

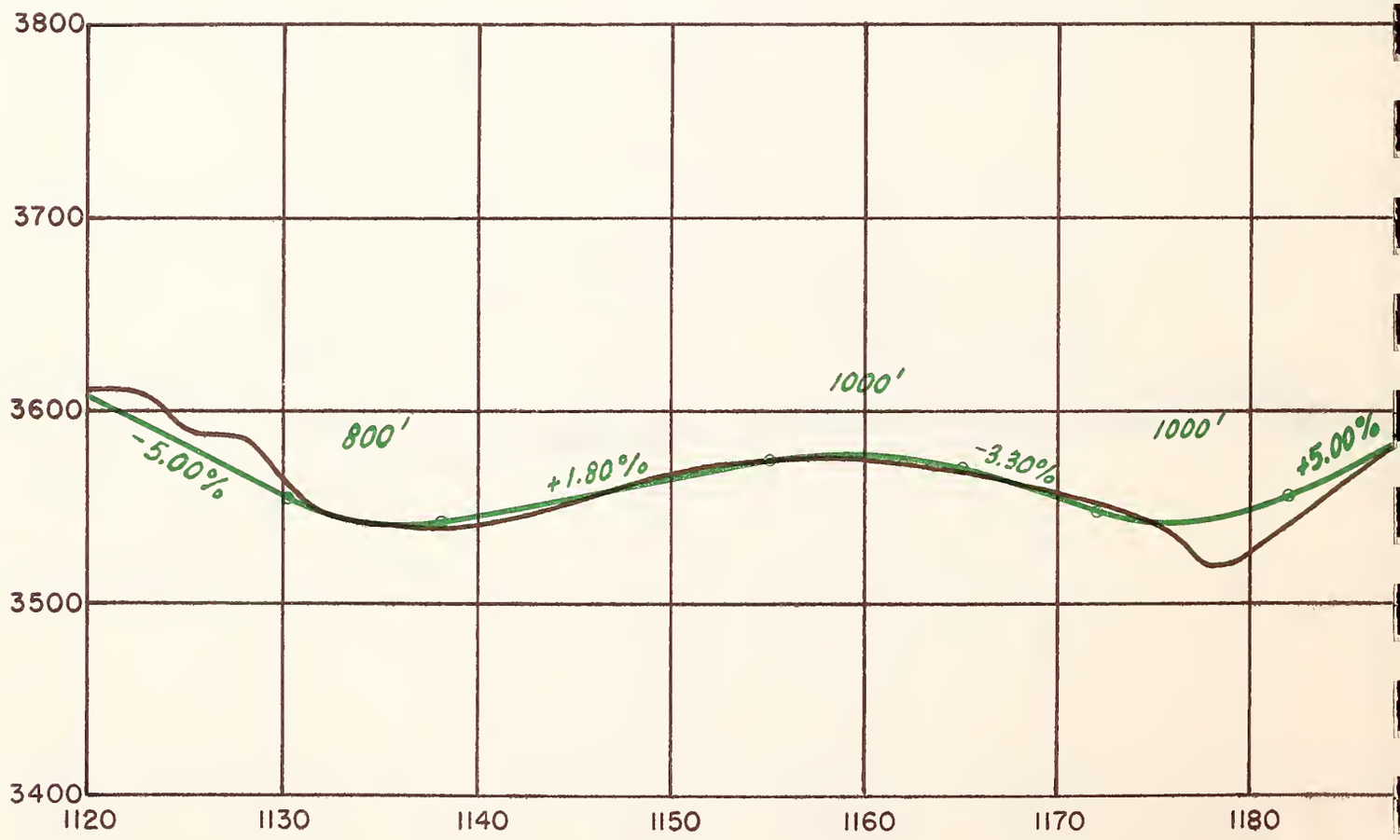
1000


3900
3800
3700
3600
3500
980
990
1000
1010
1020
1030
1040
2800'
800'
+4.00%
-3.40%

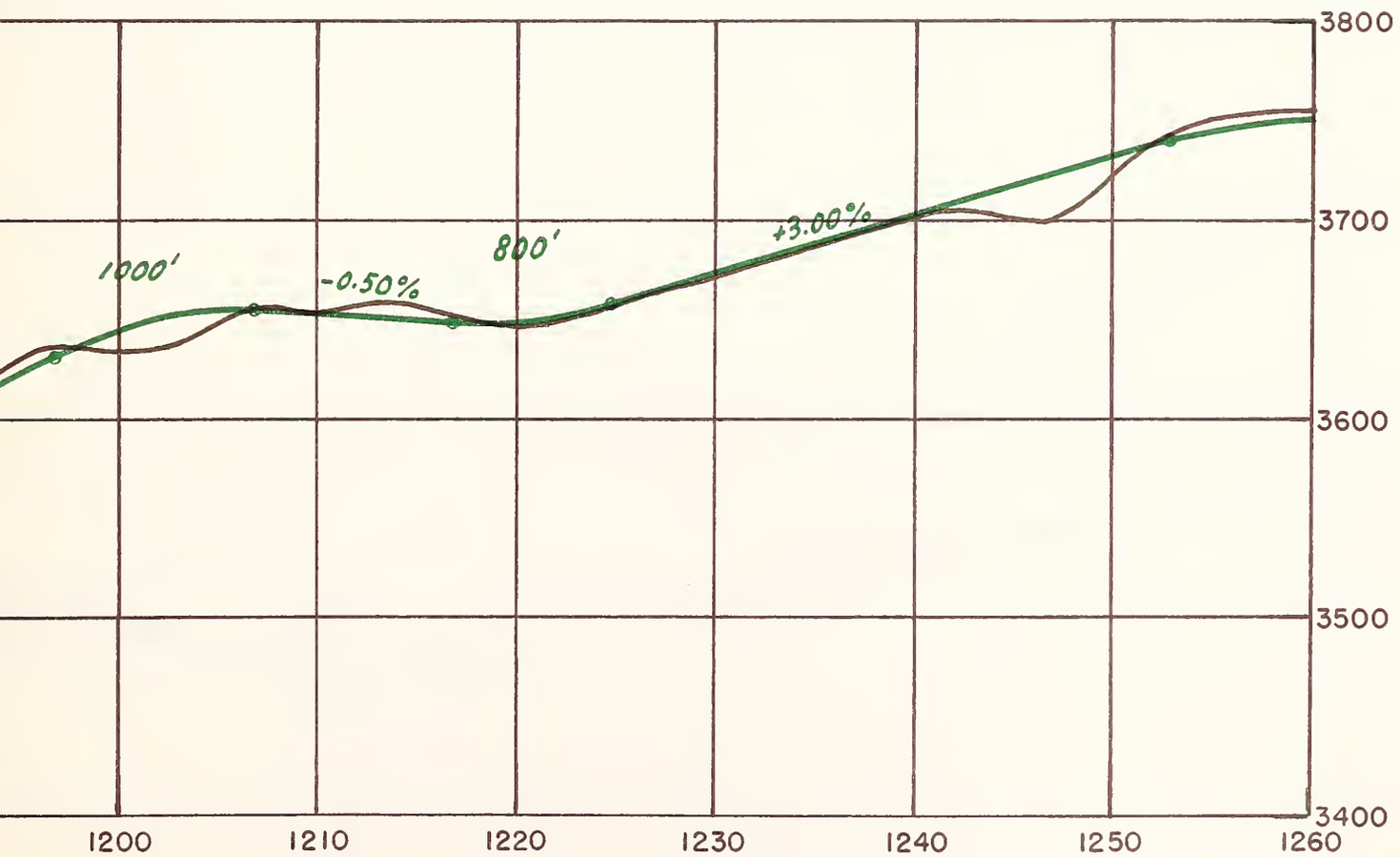
Bear
Coulee
0011
Creek
Beauvais


3900
3800
3700
3600
3500
+0.30%
1000'
-1.00%
1000'
-5.00%
1060
1070
1080
1090
1100
1110
1120

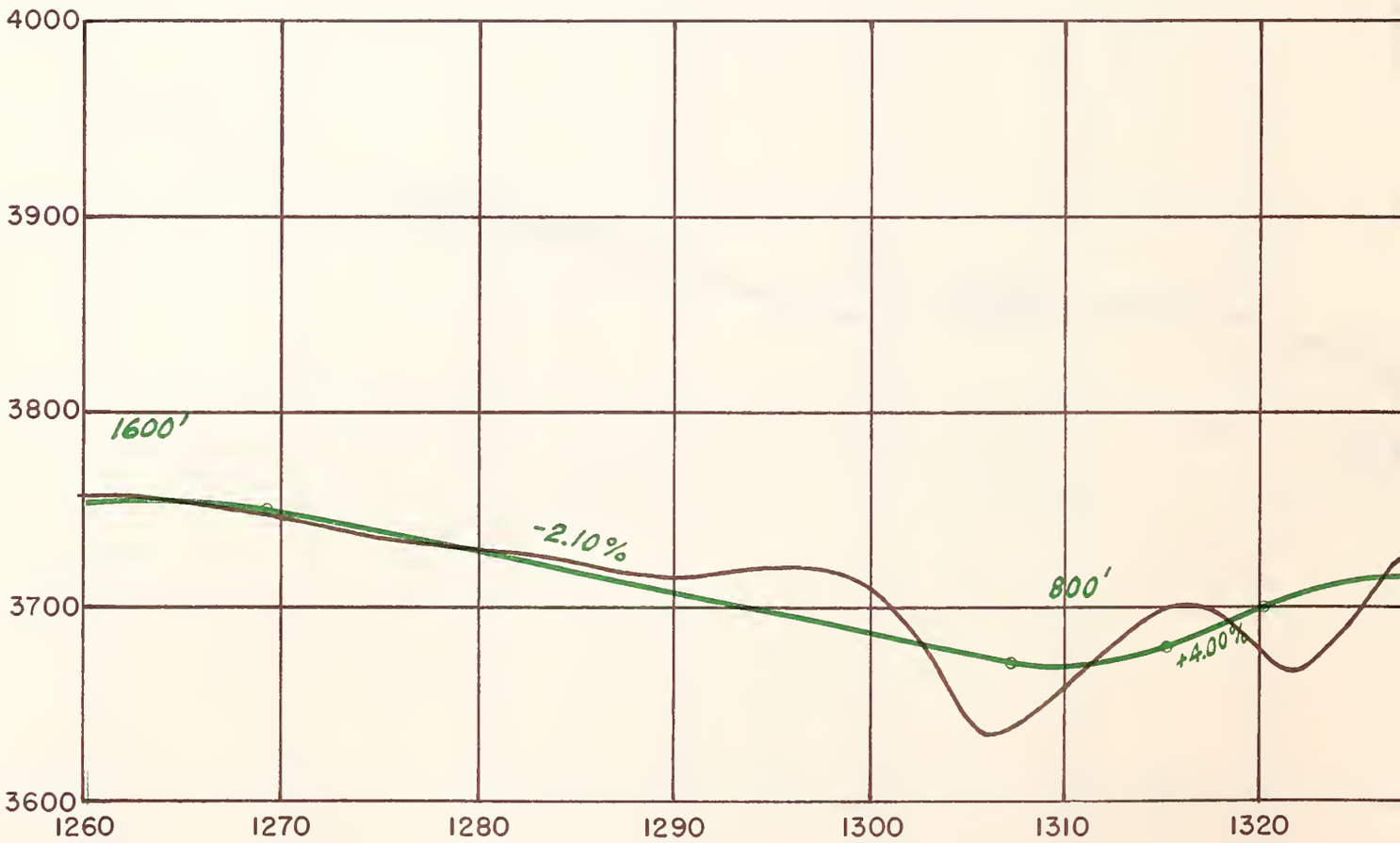

N
Creek
1150
Beaudats


3800
3700
3600
3500
3400
1120
1130
1140
1150
1160
1170
1180
-5.00%
800'
+1.80%
1000'
-3.30%
1000'
+5.00%

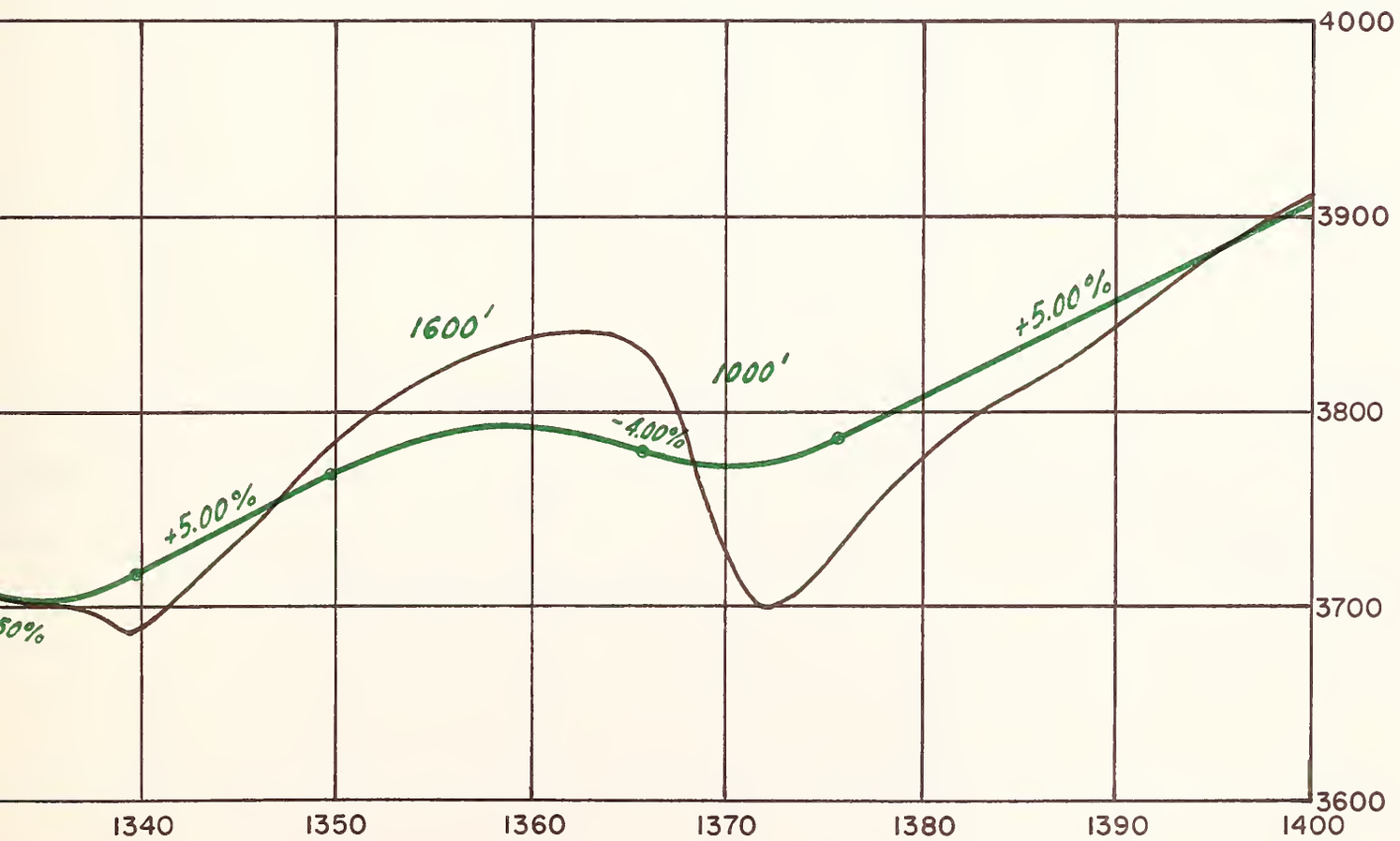
1200
1250


3800
3700
3600
3500
3400
1200
1210
1220
1230
1240
1250
1260
1000'
-0.50%
800'
+3.00%

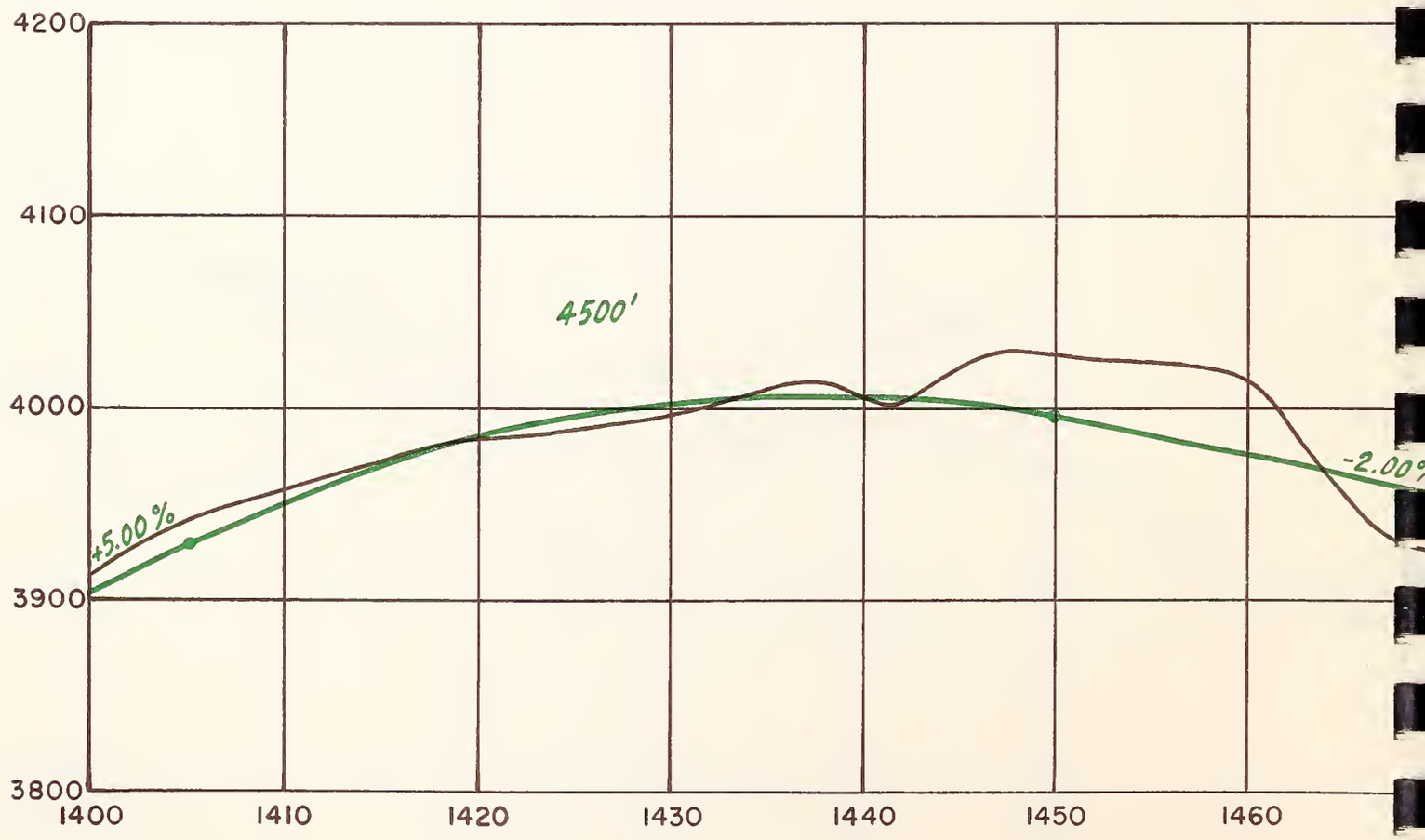
Gulch
1300
Horse
N


4000
3900
3800
3700
3600
1260
1270
1280
1290
1300
1310
1320
1600'
-2.10%
800'
+4.00%

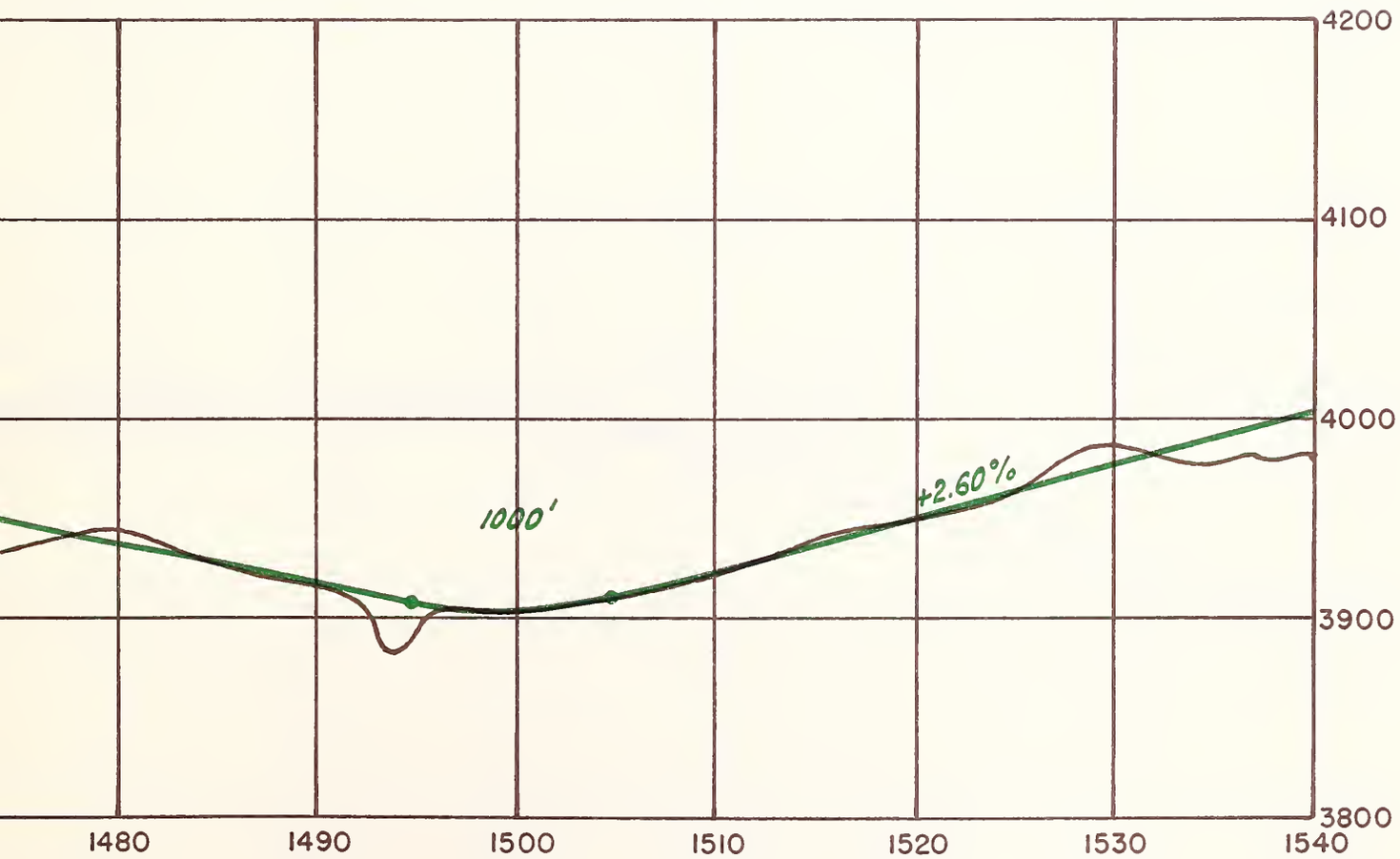
1350
Point Creek
1400


4000
3900
3800
3700
3600
1340
1350
1360
1370
1380
1390
1400
1600'
1000'
+5.00%
-4.00%
+5.00%
50%

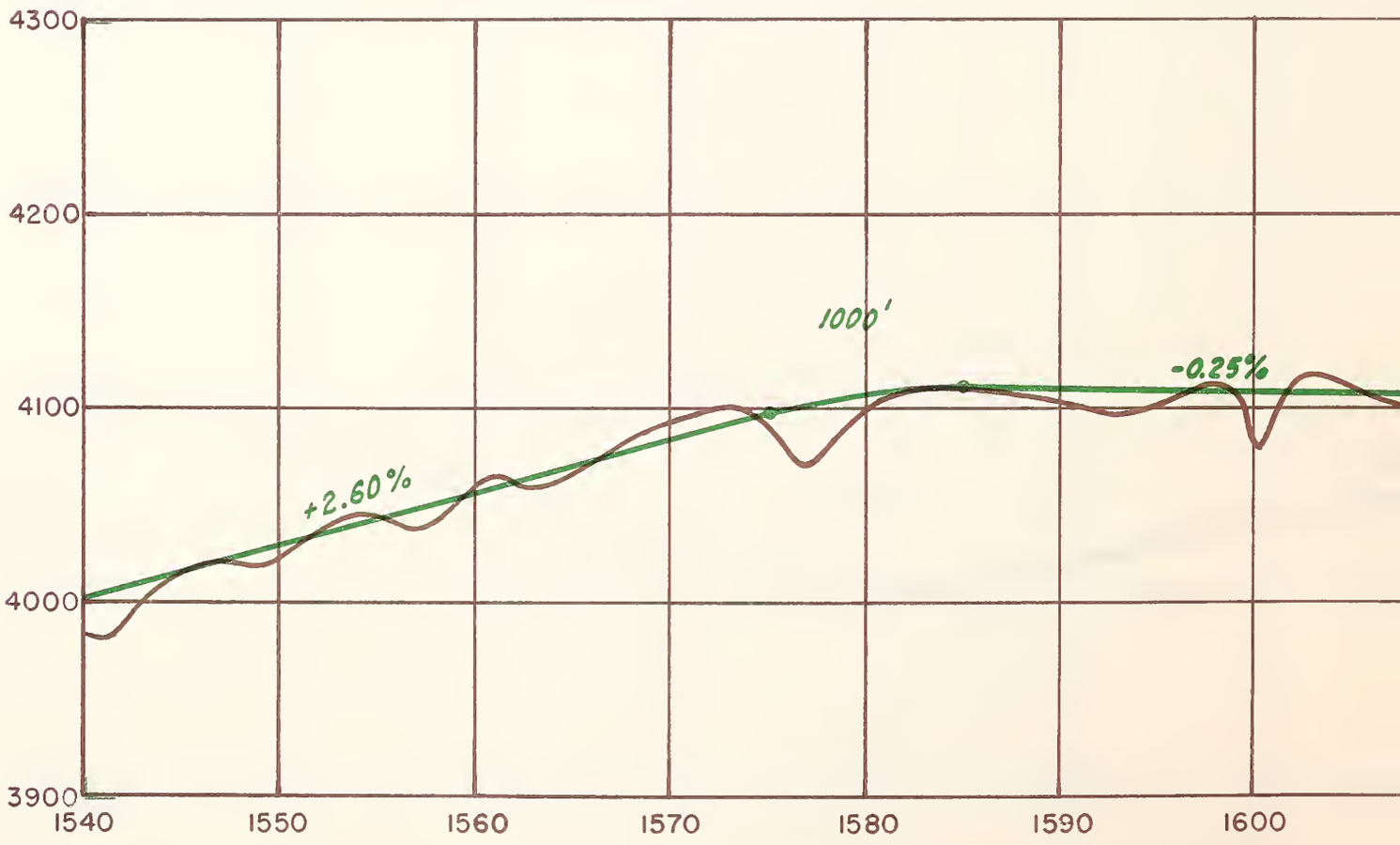
1400
N
1450


4200
4100
4000
3900
3800
1400
1410
1420
1430
1440
1450
1460
4500'
+5.00%
-2.00%

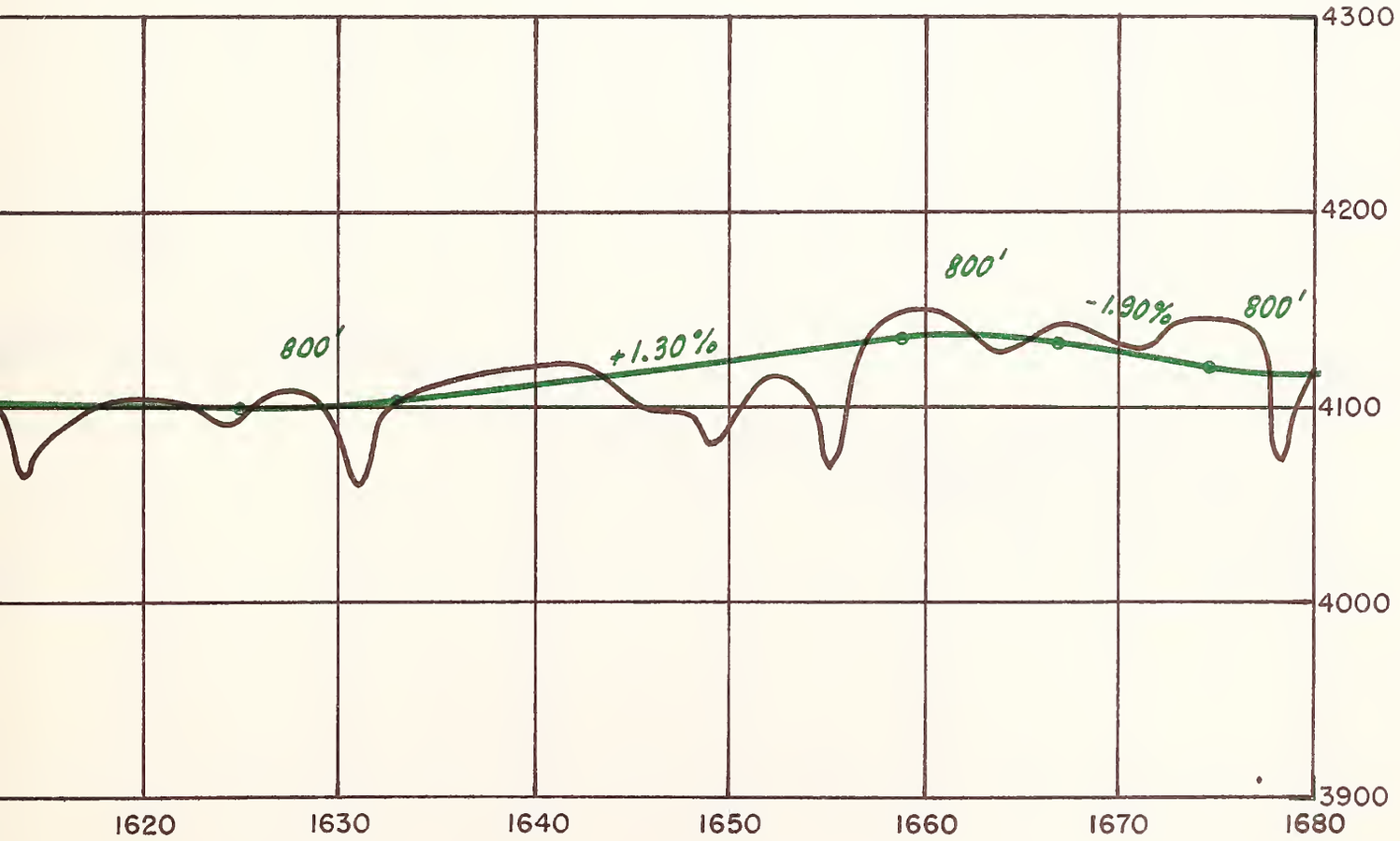
creek
1500
1550
Muddy


4200
4100
4000
3900
3800
1480
1490
1500
1510
1520
1530
1540
1000'
+2.60%

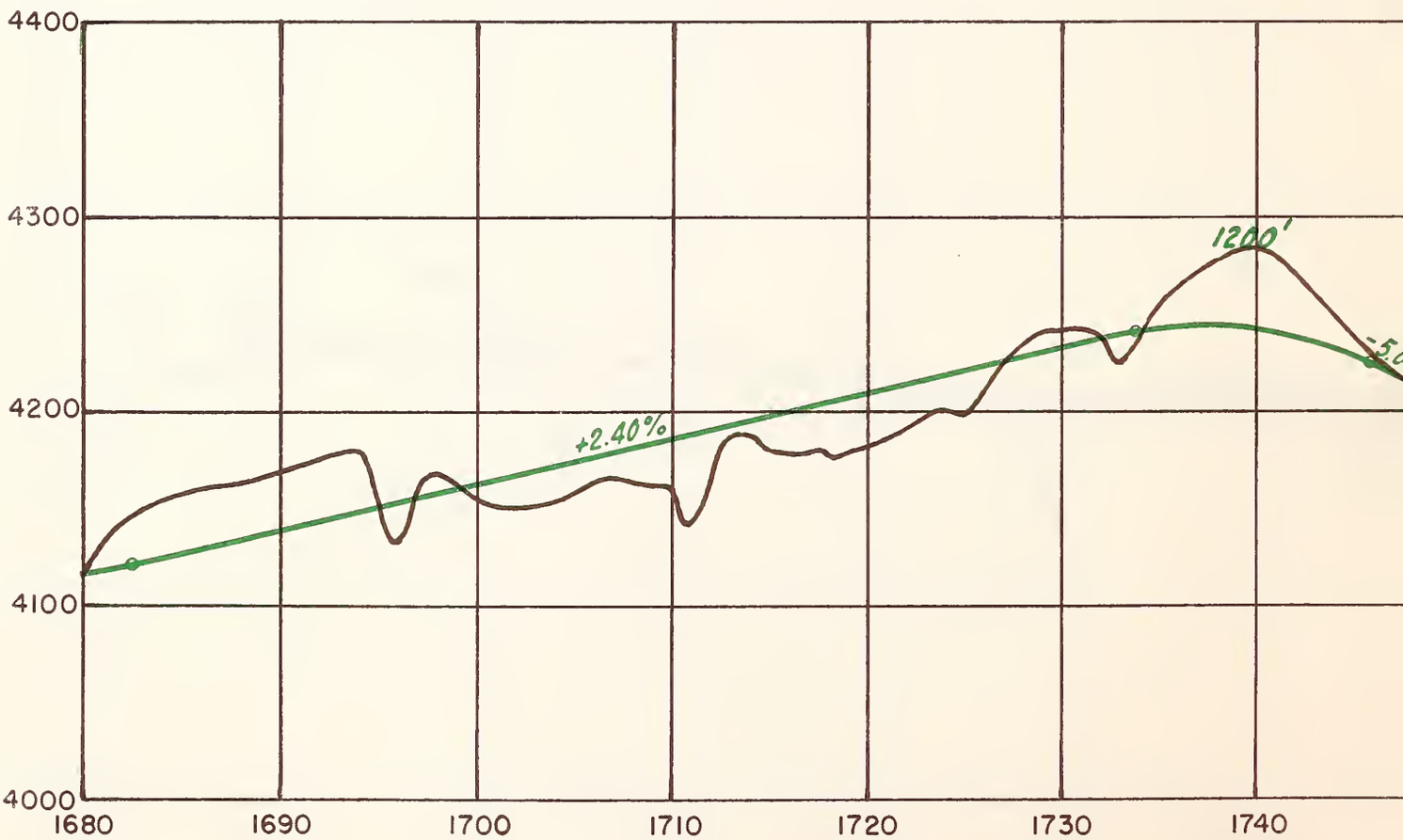
1550
1600

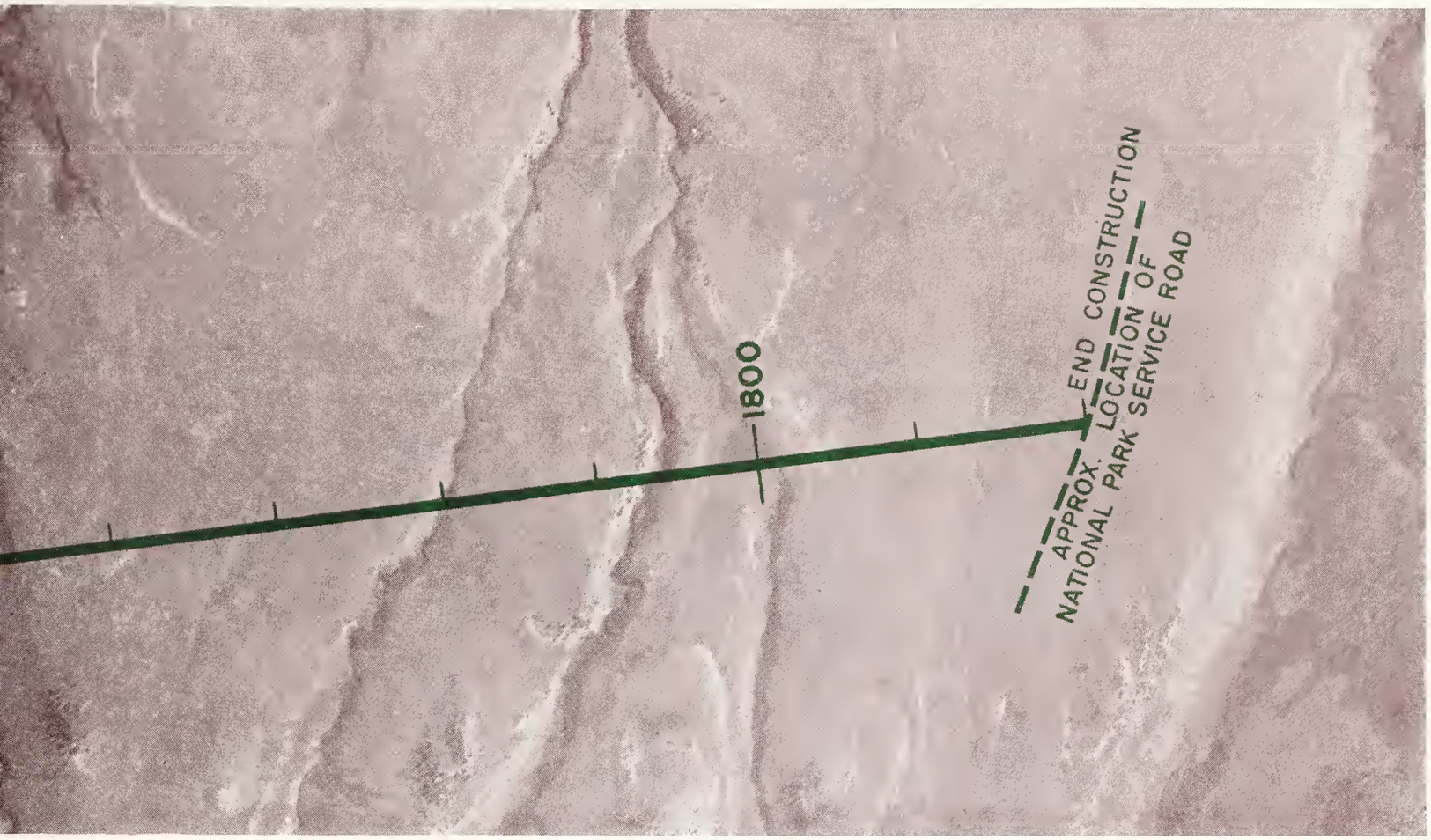

4300
4200
4100
4000
3900
1540
1550
1560
1570
1580
1590
1600
1000'
+2.60%
-0.25%

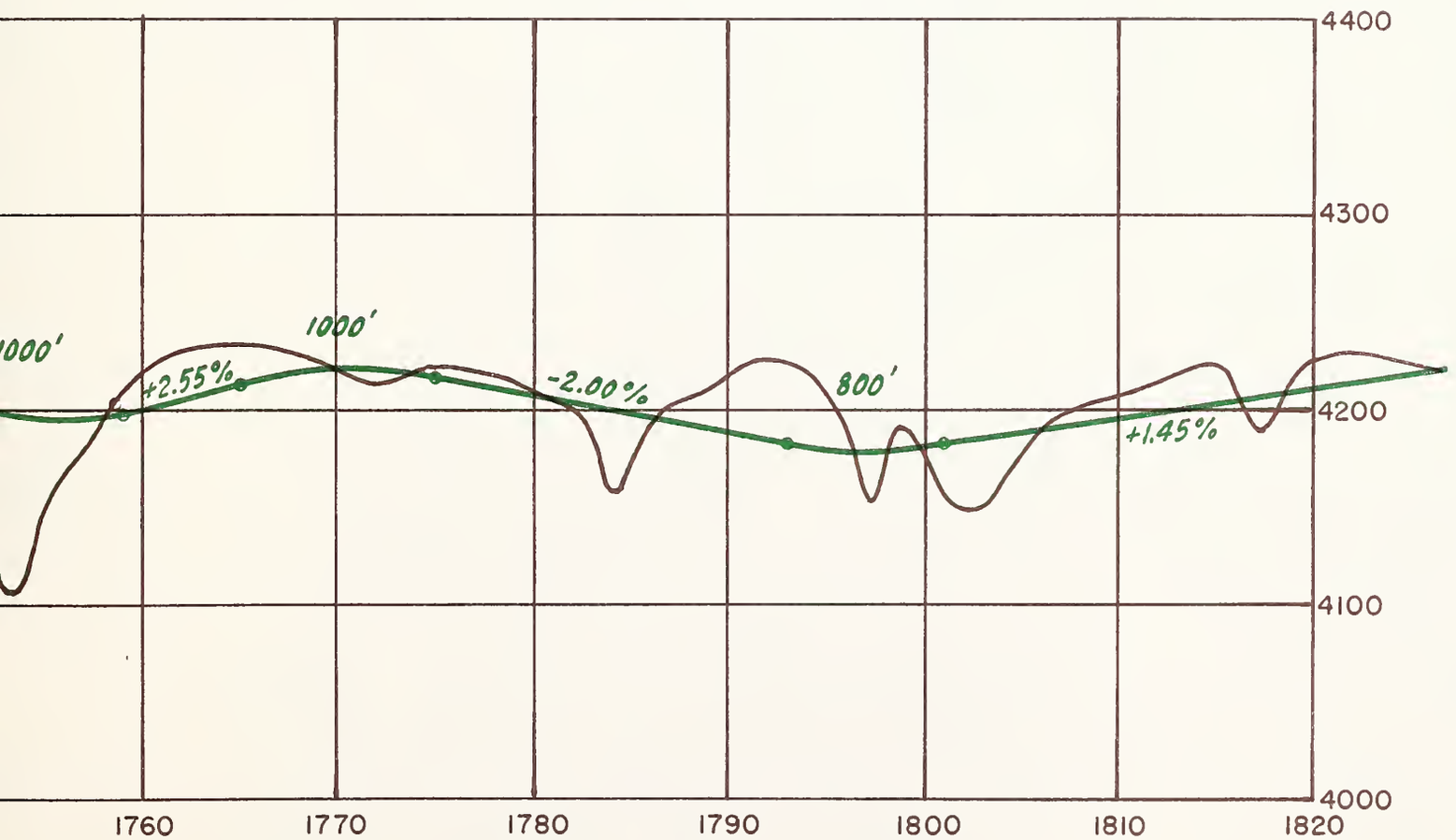
Creek
N
Cropevine
1700
Cropevine Creek
1650
North Fork
South Fork


4300
4200
4100
4000
3900
800'
+1.30%
800'
-1.90%
800'
1620
1630
1640
1650
1660
1670
1680

South Fork Grapevine Creek
1700


4400
4300
4200
4100
4000
1680
1690
1700
1710
1720
1730
1740
1200'
+2.40%


1800
END CONSTRUCTION
APPROX. LOCATION OF
NATIONAL PARK SERVICE ROAD


4400
4300
4200
4100
4000
1760
1770
1780
1790
1800
1810
1820
1000'
+2.55%
1000'
-2.00%
800'
+1.45%